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Presidential Address

THE INSTITUTE— ITS ROLE IN THE PROFESSION AND IN THE AGRICULTURAL COMMUNITY

R. M. MOORE

I make no apology for making the Institute the principal subject of my Presidential Address. Indeed, it would be inappropriate for a Presidential Address to be devoted to any other subject at the present time. As your past President I am of course, familiar with the issues confronting the Institute and I have ideas on how these issues might be resolved. Since the office of Past President is largely an inactive one, this is virtually the last opportunity I have of putting such thoughts to the membership. To promote discussion of my ideas I moved at the Council Meeting earlier today that the Presidential report be received as a report to the incoming Council.

Firstly, I would like to talk briefly of the Institute's Report on Agricultural Scientists in Australia. The compilation of this report is something with which the Institute can be justifiably proud and for which it is indebted to a number of people—so many people in fact that I perforce must limit myself to mentioning only a few. I cannot let this opportunity pass without paying special tribute to Dr. Don Williams for the tremendous amount of work he put into the survey, the resultant report, and for his continuing devotion to its cause. It is significant that right up to the final stages of its issue the report was known as the "Williams" report. The Institute also owes a debt of gratitude to my other colleague on the Report Sub-Committee, Mr. Walter Ives, who made a large contribution both to the format of the report and to the policy regarding its release. I would like to thank both of these members personally and also on your behalf.

In producing and publishing the report, the Institute perhaps for the first time in its history acted as a united and coherent body—in fact as an Australian Institute. Also, for perhaps the first time, Council has initiated a policy project, and largely by its own efforts has seen it through to completion. This, in spite of the fact that the findings of the report have been unpleasant, and to a degree humiliating, to the Institute as a professional body and distasteful to many of its members in their official capacities. The question is whether the Institute will continue to act as an Institute and pursue the implications of the Report to their logical conclusions or whether it will take the easy way out and shelve the report. There may well be institutional and other pressures exerted in the direction of the second alternative. The new Council has the responbility of analysing the facts of the Report and of deciding on a policy which will meet these facts.

To my mind the principal findings of the Report are that a large proportion of the positions available to agricultural science graduates are unsatisfactory because of the limited range of salary and opportunity offered and that these positions include those in agri-

cultural extension—a field of work acknowledged by the majority of Australia's leading agricultural experts to be of great importance to the Australian economy. Since most of those working in this field at present are unhappy—as the questionnaire to members shows quite clearly—then the chances of continuing to attract good people to extension work could be extremely small. We as an Institute cannot afford to be complacent even though the number of graduates in agricultural science is increasing and no difficulty is being experienced by them in obtaining positions. If we are to preserve and increase the status of our profession we must be interested also in the quality of the jobs available to our members.

To raise the quality of jobs in agricultural extension I suggest that the Institute should

1. Continue its efforts to place the facts of the report before a Federal Minister in the hope that the Commonwealth Government as the body most concerned with Australia's export income, might use its influence with State Premiers to improve the advancement opportunities of qualified extension workers in the State services;
2. Refuse to advertise positions for graduates which do not meet minimum professional standards of remuneration and opportunity;
3. Endeavour to persuade an Australian University to establish a post-graduate course in sociology and extension methods for agriculturalists;
4. Establish a group of private practitioners in the profession by promoting the formation of private extension groups. I will return to this subject later in my address. Suffice for the moment to point out that the existence of such a group could provide the lever necessary to raise the salaries and status of members in Government services.

I myself have drawn certain conclusions from the Report findings and I would like to put these before you, together with my other ideas about which most of you already know a little. Dr. Mayo in his address to the South Australian Branch, referred to the inaugural address of our first President, the late Dr. A. E. V. Richardson, and I propose to do the same, because I feel that it is appropriate at this time that the Institute should take stock of itself. Dr. Richardson said "The main objectives of the institute are to promote the advancement of agricultural science and to further the interests of agriculture in Australia." He said a number of other things of significance, but I propose to confine myself to a discussion of these two points—the advancement of agricultural science and the furthering of agriculture in Australia.

This afternoon two motions for which I was responsible were defeated. These concerned associates and the deletion of Article 4(iii). My advocacy of associates is well known to members of the previous Council. It has been the subject of a Presidential Address to the A.C.T. Branch, of a circular letter to members, and during my term as President I have addressed General Meetings of two Branches, one meeting of a Sub Branch, and a Branch Committee, on the subject. In spite of this, however, only a small proportion of the membership know what I have in mind. After all, general meetings seldom attract more than 25 members. The problem of communication is a real one. How does one get in touch with the membership? In spite of the fact that I travelled from Queensland to Western Australia on Institute business, I found it extremely difficult to reach the great bulk of our membership. I had to decide, therefore, on whether to put my motions before an ill-prepared membership, or perhaps let them sink into oblivion. I had hoped that Branches would have informed their members of the pros and cons of each issue rather than, as some did, merely issue how to vote instructions. Council must assume responsibility in such matters and should, I believe, issue a newsletter at least annually. In this newsletter Council activities, as well as important issues, should be carefully and impartially discussed so that members will be completely aware of the pros and cons in such matters. It is not good enough to say, for example, that such and such an issue has been discussed or voted on before. I sincerely hope that some of the motions defeated today will again be put be-

fore the membership, with, I repeat, a full discussion of their implications. It was partly to achieve this purpose that I moved this afternoon that the Presidential Address be submitted to the incoming Council for discussion. These two motions form the basis of what I consider to be a coherent plan by which the Institute can at once strengthen its professional role and at the same time further the interests of agriculture in Australia.

In brief, my plan is this—

1. To retain and strengthen the present professional organisation of the Institute by admitting to corporate membership only those with university degrees—hence the reason for suggesting the deletion of Article 4(iii). The deletion, however, is not essential to my plan. It could still be put into operation with the retention of 4(iii). However, it would certainly be a much neater and tidier plan if non-graduates were excluded from corporate membership.

2. To meet the specialist interests of a diverse membership, to encourage the formation of specialist societies within the framework of the Institute by encouraging the affiliation of existing scientific societies with interests allied to those of agriculture.

3. To widen the sphere of interest of the Institute, to stimulate the exchange of views among research workers, extension workers and practising agriculturalists, to overcome the difficulty of affiliated societies with membership eligibility rules different from our own and to promote Institute activities in country areas where the number of graduates is too small to form a working group, by admitting those not qualified under Article 4(i) or 4(ii) as associates of the Institute. We have already voted to admit companies as associates. No-one can claim that companies have professional status, so why should we quibble about admitting people with a real interest in agriculture to a non-professional part of our Institute?

4. To actively promote the formation of regional Branches—i.e., to split up State Branches where desirable, forming regional units, without taking cognisance of State boundaries—e.g., a Riverina Branch could be formed, including northern Victoria and south western New South Wales. If associates were to be accepted, there seems no reason why the New England Sub Branch should not become a full Branch. Similarly, there may be a case for a Branch comprising the western districts of Victoria and the south east of South Australia.

5. To promote the dissemination of agricultural research findings to agriculture and to provide the means by which agricultural problems can be channelled back to the research worker by encouraging the formation of private extension groups. The latter as far as I can determine, would seem to be the Farmers' Clubs of Dr. Schapper.* I can think of no better service we can do for agriculture than to promote the establishment of such extension groups. I have had this in mind for a long time and indeed mentioned it briefly in my talk to the New South Wales Branch. I have hesitated to air it too widely for fear of mis-interpretation by State Departments of Agriculture and consequently of prejudicing their reaction to the Institute's Report. However, as Dr. Schapper has independently advocated such extension groups, there no longer seems to be any need for caution in this respect. I am not entirely familiar with the details of Dr. Schapper's scheme, but in essentials it seems similar to mine. Australia is a large country, and its agricultural areas are correspondingly extensive. With such a small population as we have I don't believe that governments can afford to appoint the number of extension officers necessary to give the individual farmer the detailed advice he needs. Nor is it possible for extension workers covering some hundreds of farmers, often carrying out diverse forms of agriculture, to become sufficiently familiar with the environments and problems of individual farms. I be-

* Schapper, H. P. (1959)—Farm management clubs for Australia. *J. Aust. Inst. Agric. Sci.* **25**: 23-30.

lieve farmers should be and would be willing to pay for such services. I don't envisage that the role of the Departments of Agriculture would be minimised in any way. Rather would it be enlarged by the necessity of strengthening their regional extension groups which would provide the specialist officers and be the principal sources of information to the private extension man. The latter could be registered by the Institute and the existence of a body of private practitioners within the Institute would provide the lever needed to raise the salaries and status of members in the Government services.

If Regional Branches and Associates become part of the Institute, it is easy to see that country Institute meetings could thus be of the nature of extension, and also a channel through which problems could be passed back to the research worker whether he be in the city or in the country.

6. To meet this possible new demand for extension workers, but in fact irrespective of whether private extension groups are formed or not, the Institute should urge universities to take cognisance of the need to train undergraduates in extension methods. We should endeavour to get one Australian university to provide courses in such methods.

Finally, I believe that the Institute should use whatever influence it has to urge the Commonwealth Government to set up a body similar to the British Agricultural Research Council for the purpose of investigating the research needs of industry and to disperse the funds now being collected from such primary industries as wool, wheat, dairying and beef cattle. It is only by the operations of a completely independent body such as this, capable of carrying out its own investigations, that the best use will be made of these funds.

To achieve these objectives, I believe that Council should appoint a number of subcommittes to investigate each proposal. For example, a committee should be set up to examine and if necessary revise, the whole of the Constitution to meet the needs I have outlined and to remove existing anomalies such as the lack of sufficient continuity of representatives on Council, the unsatisfactory voting system in Council and to clarify the roles of Central Office and Council, and to strengthen the executive functions of the latter. The Agricultural Research Council proposals and the private extension group proposal should also be worked out in detail by Council sub committees.

Errata

Volume 25, No. 3. Pages 91 and 117.

The senior author of the Review,"*Sorghum almum* Parodi—a valuable summer-growing perennial grass", should read—

Dr. J. Griffiths Davies, Associate Chief, Division of Plant Industry, C.S.I.R.O.* in place of—

Dr. J. Griffith Davies, Assistant Chief, Division of Plant Industry, C.S.I.R.O.

*Dr. Griffiths Davies is now Chief, Division of Tropical Pastures, C.S.I.R.O.

WC144

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THE COMMERCIAL MUSHROOM INDUSTRY IN N.S.W.

R. J. CONROY

Commercial culture of the mushroom *Agaricus hortensis* (Cke.) Imai, had, in 1958, reached the stage of a primary industry with a gross annual output valued at some £400,000. This article reviews the industry over the last 30 years.

Commencement of the Industry

Although commercial mushroom culture had been a well established industry in Europe and the United States for many years (Atkins 1952, Kligman 1950), attempts to culture mushrooms in New South Wales were relatively unsuccessful before 1930. Noble (1931) records that practically all the mushrooms offered for sale at the Sydney Municipal Markets were those which had grown under natural field conditions, e.g., *Agaricus campestris* L. The supply was unequal to the demand at the time and Noble forecast that a ready market would exist for cultivated mushrooms provided that supplies were made available frequently.

Noble carried out a number of experiments in the cultivation of mushrooms in the early 1930's. These trials were based on the methods which had been described by overseas authorities (Charles 1929; Ware 1931; Lambert 1932) and Noble was able to show that mushrooms could be cultured in the Sydney Metropolitan Area provided that the recommended procedures were followed. This work stimulated the interest of a number of private persons in the possibility of commercial mushroom culture and there was a subsequent steady expansion of the industry in the Sydney area. Ventures at that time were almost entirely in tunnels, sheds, and cellars. Amongst the most notable ventures in this period were those in the tunnels of the then uncompleted Circular Quay-St. James railway (Figure 1), tunnels at Glenbrook, Lithgow and Picton, the pylons of the Sydney Harbour Bridge and the old brick kilns at Ryde.

Expansion of the Industry

In 1934 mushroms were cultured for the first time in outdoor ridge beds and, during 1936, some growers in the outer Sydney Metropolitan Area commenced to use this system of culture. In this method of cultivation the prepared compost is moulded to form a ridge about 2ft 6in. high, 2ft 6in. at the base and of any convenient length (Figure 2). The beds, after casing, are covered with a layer of fresh straw about one foot thick which is in turn covered with bagging. This covering of straw and bagging protects the beds from mild weather changes and provides some insulation (Figure 3).

Outdoor ridge beds possessed both advantages and disadvantages compared with the more controlled indoor culture, that was the

R. J. Conroy is a Plant Pathologist with the New South Wales Department of Agriculture.

Figure 1—Mushroom Culture in the Circular Quay-St. James Railway Tunnel in the early 1930's.

most widely practised method overseas. Build up of diseases was avoided to a reasonable extent by locating the ridge beds on different areas of the property each season. The cost of erecting a permanent structure was avoided. However, there was a greater danger of insect and mite infestation because the beds rested on the ground and space fumigation could not be practised. Facilities for peak heating were not available and badly prepared composts frequently resulted. Very accurate control of temperature and humidity could not be maintained in outdoor ridge beds during cropping with the result that production was depressed by cold weather. Also extremes of weather such as heavy rain and high winds could reduce outdoor production. Furthermore, mushrooms produced in outdoor ridge beds being in contact with the overlay of straw, had more blemishes than those produced in tunnels, sheds, etc., where the straw overlay was not necessary. During picking the straw covering had to be removed and subsequently replaced.

Outdoor mushroom culture continued to expand during the late 1930's and early 1940's. By 1947, the quantity of mushrooms produced in outdoor ridge beds was 80

Figure 2—Spawning Outdoor Ridge Beds.

Figure 3—Outdoor ridge beds in bearing. The straw covering has been removed.

to 90 per cent. of the total production. Outdoor ridge bed production was located in an area bounded by Parramatta, St. Marys, Windsor, Riverstone and Pennant Hills with the major concentration of growers at Oakville and Maraylya in the Windsor area. The remaining 10-20 per cent. of the mushrooms was produced in tunnels and other enclosed structures in and around the Sydney Metropolitan Area. At Oakville and Maraylya, the principal primary income before the development of mushroom culture came from poultry raising with fruit and vegetable growing as subsidiary industries. By the late 1940's mushroom culture had become a very significant source of income and, on some properties, it had become a whole time industry. The larger growers then handled up to 10,000 square feet of bed. (One running foot of ridge bed = approx. four square or "surface" feet.) Areas over 5,000 square feet usually required the employment of additional labour.

Although details of the construction of mushroom houses had been published in the early 1930's (Ware 1931, Lambert 1932) local growers were not prepared to outlay the capital necessary to construct houses of this type in the early years of the industry. During World War II a general shortage of suitable building materials precluded the construction of mushroom houses. Up till 1950 one mushroom house had been constructed of timber—with steam heating for temperature control in winter.

The Industry in Recent Years

By 1950, the gross annual value of the crop was about £200,000. The bulk of the mushrooms was sold at the Sydney Municipal Markets and the remainder was disposed of at roadside stalls, or by private contract. However, after 1954 food processors sought increasing quantities of mushrooms for canning and soup making and since then there has been a marked increase in production, which reached about two million lb in 1958.

Until June, 1958, the quantities of mushrooms used by food processors were included in the records of the State Government Statistician with a number of other processed primary products. However, since July, 1958, separate records of the quantities of mushrooms delivered to processors have been kept. The available figures are as follows:—

July, 1958	145,500 lb
August, 1958	295,000 lb
September, 1958	438,000 lb
October, 1958	389,000 lb

There has been an increase in the number of mushroom houses constructed in the County of Cumberland and some houses have also been constructed on the highlands to the south and west of Sydney. In the Metropolitan area there has also been an increase in outdoor ridge bed production and many sheds and fowl houses are being used. Mushroom culture is a full time industry for those growers who have erected mushroom houses, whereas in the case of over 50 per cent. of other growers, mushroom culture is combined with fruit and vegetable culture, poultry raising or dairying.

Cultural Materials

Until recent years horse manure composts were the most widely favoured among growers. Fresh horse manure from stables, already contained a straw component, thus eliminating

considerable labour in making the compost heaps. However, over recent years supplies of fresh horse manure have become increasingly costly and difficult to obtain and other animal manures, principally sheep, poultry and cow manure, have been substituted.

Although formulae for synthetic (i.e. non-manure) composts had been published for many years (Lambert 1932; Sinden 1938), the development of a satisfactory synthetic compost was considered to be largely in the experimental stage such composts were not used by outdoor ridge bed growers. It is only in the last 3-4 years that noteworthy interest has been taken in synthetic compost and this by indoor growers. Successful crops have been produced by these growers using the English formula (Atkins 1952) and an American formula (Sinden 1938).

In indoor culture many beds are now cased with peat moss. This practice has a decided advantage over soil casing in that the moisture holding capacity of the peat substantially reduces the number of waterings required during the growing period.

The Growing Season

In the County of Cumberland, production is greatest during the cooler period of the year —May to September. In cool springs production may continue till November. The mushrooms produced during the remainder of the year come from tunnels on the outskirts of the Metropolitan Area where there is little temperature variation over the year, or from mushroom houses on the highlands. Even in special houses in the County of Cumberland, investment in cooling equipment which would enable production to continue over the summer months has not yet been considered worthwhile by growers.

Structures

Those insulated houses which have been constructed are along the lines of the American unit house. The walls are of double brick, porous brick, or timber or fibro with an inner lining. These houses have produced satisfactory crops at the appropriate periods of the year particularly when steam heating pipes have been installed. Less satisfactory are galvanized iron sheds and converted poultry houses where temperature control is not possible in winter. A recently constructed double wall brick mushroom house (American type) with a capacity of 1800 square feet of bed cost £1000 plus labour.

Spawn

When overseas cultural practices were applied under local growing conditions in the early 1930's, one of the principal limiting factors in production was the lack of good quality, reliable spawn. Some imported spawn was sold commercially but its use was mostly followed by crop failures because it was not viable when purchased by growers. Using pure cultures imported from the United Kingdom and the United States, Noble first prepared pure culture compost spawn in 1931 at the Biological Branch of the New South Wales Department of Agriculture. However, until 1933 only brick spawn was available to intending growers. Some brick spawn was made locally about this time. This spawn was prepared from a mixture of fresh horse manure or cow manure and litter which, in a semi-soft condition was moulded into rectangular bricks which were then inoculated with mushroom mycelium. When thoroughly permeated, the bricks were stored, dried and offered for sale. Naturally, many failures followed the use of these bricks for, apart from those in which the spawn had died, the organisms of mushroom diseases or insect pests could easily be present in the bricks. The compost spawn prepared by Noble using the best overseas strains proved much more reliable than did brick spawn. In 1933, the New South Wales Department first made available compost spawn to growers and this considerably assisted the development of the industry (Noble 1936).

The next notable local advance in the industry was the introduction of pure culture grain spawn. This spawn was first successfully prepared by Dr. J. W. Sinden at the Pennsylvania State College, U.S.A., and details of his process were made available to the New South Wales Department in 1939. Although compost spawn was by this

time widely used, the preparation of grain spawn under pure culture conditions, enabled a surer product to be obtained. Grain spawn also possessed advantages over compost spawn in that it commenced to run more quickly after insertion in the beds and only half the quantity of spawn was required to plant a given area of bed. The disadvantage of grain spawn was its attraction to mites and rodents. After its introduction pure culture grain spawn rapidly increased in popularity, replacing compost spawn. By the early 1940's brick spawn manufacture had almost ceased.

Practically 100 per cent. of the spawn now produced in New South Wales is pure culture grain spawn. Some half dozen specialized commercial spawn producers supply the requirements of the industry. Spawn of the white and brown strains of mushroom produced originally at Pennslvania State College was introduced in 1948. The brown strain did not find a ready sale on the fresh market but is now being cultured to some extent for the canning trade.

Diseases and Competitors

Parasitic diseases of the growing crop are sporadic in occurence, at times causing significant losses in individual beds, but widespread outbreaks are rarely recorded during any season (N.S.W. Plant Disease Surveys 1933/4 to 1956/7). The parasitic diseases recorded in New South Wales are bubbles (*Mycogone perniciosa* Magn.), brown spot (*Verticillium* sp.), mildew (*Dactylium dendroides* Fr.), and a bacterial spot (*Bacterium* sp.). Recently, mat disease (*Myceliophthora lutea* Cost.) was recorded for the first time in New South Wales at Maraylya, where it had severely depressed the yield in individual outdoor beds. A condition resembling damping off or wilt attributed by Wood (1937, 1939) to competition from *Fusarium* species, has been recorded once, in indoor beds. Mummy disease (Tucker and Routien 1942) has not been recorded in New South Wales. A watery rot of the mushroom somewhat similar to that described by Wood (1950) has been observed in individual mushrooms but only once has it caused a practically complete crop loss.

In indoor culture measures are taken for the control of parasitic diseases. These include application to the beds of zineb for bubbles and brown spot (Lambert and Ayers 1953; Yoder, Sinden and Hauser 1950) and pentachloronitrobenzene (P.C.N.B.) for mildew (Stoller *et al.* 1956; Gathercole 1957; Cleary 1958; Goodman 1958). Prompt application of two per cent. formalin spray to individual areas of beds where bubbles and brown spot have appeared has been found most effective.

In outdoor ridge beds, where no direct control measures are normally applied for control of bubbles and brown spot, a number of factors contribute to the generally low incidence of these diseases. These factors include location of ridge beds on different areas of the property each season, disposal of spent compost for garden humus and sterilizisation of casing soil with formalin or use of subsoil for casing.

The most common competitors, or mushroom bed invaders, that are encountered are the brown plaster mould (*Myriococcum praecox* Fr.) and ink caps (*Coprinus* spp.). The effect of these fungi on cropping does not appear to be significant. The white plaster mould (*Scopulariopsis fimicola* (Cost. and Matr.) Arn. and Barthelet) is of rare occurrence. Truffle (*Diehliomyces microsporus* (Diehl and E. B. Lambert) Gilkey) is troublesome only when attempts are made to culture mushrooms in the warmer months of the year. The olive green mould (*Chaetomium* sp.) often appears in badly prepared composts. Green moulds (*Penicillium* spp. and *Trichoderma viride* (Pers. ex Fr.) sometimes cause concern when they become established before the spawn starts to run.

Recent investigations (Blake and Conroy 1959) have shown that high populations of nematodes in composts in the absence of other parasitic organisms are associated with low yields in a number of beds. The importance of nematodes in depressing mushroom yields has become increasingly recognised overseas in recent years (Cairns and Thomas 1950; Lambert and Ayres 1953; Thomas and Mitchell 1951; Van Haut 1956).

The principal nematodes recovered from local mushroom beds are *Ditylenchus myceliophagus* (J. B. Goodey) and a complex of *Rhabditis* species.

A disease of mushrooms of undetermined origin, known as white gill, pale gill or flock, causes some losses particularly in the later flushes in both indoor and outdoor beds. The names of the disease are descriptive, the gills are pale, very short and with extra development of tissue at the base. There does not appear to be any consistency between the occurrence of the disease in flushes and the location of affected mushrooms in the beds.

Insect Pests

Two groups of pests may interfere with mushroom culture. Firstly, flies, springtails and mites can be very damaging to both immature and mature mushrooms, and can also feed upon the mycelium. Infestations by these insects can usually be expected for the organic materials used in the culture of mushrooms are highly favourable for their biological requirements. Where preventive measures are not carried out to control this group of pests, subsequent effective control by chemical means is often difficult to obtain. Secondly, slaters, slugs, mole crickets, rats and mice can reduce yield by direct damage to the mushroom or, in the case of crickets, by burrowing into the beds. Again, preventive measures have proven satisfactory for minimizing infestation, but these pests are more readily controlled chemically than flies, springtails and mites.

Flies, Springtails and Mites

Two types of flies are found inhabiting mushroom beds, namely fungus gnats, probably *Sciara* sp., and manure flies (*Phoridae*). Cecidomyiid flies are probably also established in New South Wales. The larvae of these flies feed and develop within the beds. Larvae of some species may be found in the stem and cap of the mushroom.

Since the larvae are to be found mainly in the beds, attempts have been made to combat them by mixing insecticides into the compost and casing soil. BHC has been employed in New South Wales for the past ten years (Shanahan 1948), but it is now doubtful whether this gives adequate control and further work is required to establish the value of both BHC and alternative insectides. English workers are currently suggesting that repellents may have a place in deterring flies from depositing eggs on compost beds. This approach is novel and holds promise (Hussey 1958).

Tyroglyphid and Tarsonemid mites (*Tyrophagus putrescentiae* Schr. and *Pygmaeophorus americanus* Banks) can reduce yields. The former mite feeds on both the mycelium and the fruit whereas the latter is suspected of eating the mycelium. As with mushroom flies, satisfactory control measures have yet to be developed for combating established infestations of these pests. Furthermore, it is debatable whether the incorporation of BHC into the beds and casing soil will act as an adequate preventive measure.

In the absence of peak heating and space fumigation facilities emphasis has been placed on hygiene and preventive measures for the primary control of these pests.

Springtails (*Hypogastrura armata*, Nicolet and *Onychiurus ambulans* L.) consume both the mycelium and mushrooms. Surface dusting with BHC is an effective remedy against springtails above and within the casing soil but has little value against the insects within the compost beds.

Slaters, Slugs and Mole Crickets

Both slaters and slugs are suited by the conditions prevailing in and around mushroom beds, but these minor pests are readily controllable; the former by merely dusting of the surface of the beds with BHC whilst the conventional metaldehyde bait will reduce slug numbers. Spraying ground adjacent to beds with two per cent. chlordane will considerably reduce mole cricket numbers.

Rats and Mice

Although these animals can reduce yield by burrowing into the beds and nibbling at the mushrooms, the main danger from rats and mice is at spawning when grain spawn is used for seeding the beds. Traps and proprietary baits, used in accordance with directions, have provided satisfactory control.

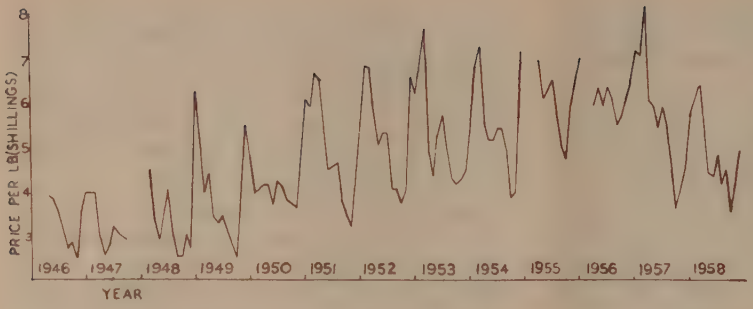

Figure 4—Average Wholesale Prices of Cultivated Mushrooms at the Sydney Municipal Markets, 1946 to 1958.

The Economics of Production

The costs of production are variable, depending largely on the outlay necessary for the purchase of the basic materials. Since the late 1940's there has been a substantial rise in the cost of horse manure and straw. In 1948 horse manure obtained from stables cost £1-£2 per ton and fresh baled straw £4-£5 per ton. Today stable manure costs £5-£8 per ton and baled straw £15-20 per ton. Spawn retails at 10 to 12 shillings per quart bottle, and labour required costs about £3 per day. It has been estimated that the overall costs of production for the fresh market are 2s. to 3s. per lb today compared with 1s. 6d. per lb in 1948.

The wholesale prices obtained for fresh mushrooms at the Sydney Municipal Markets since 1941 are shown in Table 1. An early record (Anon. 1934) states that prices of 2s. 3d. and 3s. per lb were obtained at city stores in 1934. The prices shown in Figure 4 indicate:—

1. A general upward trend to 1958.

2. The highest average returns are obtained for the relatively small quantity of mushrooms grown in tunnels or in houses on the highlands which are sold over the summer and early autumn period.

3. A depression in the prices for mushrooms in the spring months, usually the end of the crop from outdoor ridge beds and houses and the mushrooms are of poorer quality than those grown during the winter months.

4. A rise in the mid-winter due to cooler weather depressing the output.

Mushrooms sold to canneries and food processors generally realize 3s. 6d. to 5s. per lb, which includes stalks. For canneries special packaging is not required and transport costs and agents' commission is obviated, a saving of some 6d. to 9d. per lb.

Future of the Industry

It would appear that any further expansion of the industry will be dependent on outlets other than the fresh market. The demand by processors will doubtless determine the total amount of mushrooms grown and the amount which reaches the fresh market will not increase substantially with a consequent maintenance of prices similar to those which have obtained during recent years. A set contract price without the cost of careful packing, transport and agent's commission is favoured by the growers. Processing, however, demands a constant supply of mushrooms and this could militate against the variable supplies from the outdoor ridge beds and favour the grower who is prepared to build proper mushroom houses or grow in other structures where a continuity of supply can be expected, e.g., tunnels. Futhermore, the cleaner product obtained from indoor beds is favoured by the canners so that, eventually, less efficient ridge bed production may experience some recession. There is an increasing interest by experienced outdoor growers in the use of mushroom houses.

Acknowledgements

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MUST PEOPLE STARVE IN THE TWENTIETH CENTURY?

R. H. GREENWOOD

One of the most striking features of the post-war world has been a notable acceleration in the rate of world population increase. According to the latest (1957) edition of the United Nations' *Demographic Yearbook,* the total number is estimated to have increased from 2,495 million in mid-1950 to 2,737 million in mid-1957. The current annual rate of increase is about 1.6 per cent. and this represents the addition of some 45 million people a year or 123,300 every day to the world's population.

There seems to be little doubt that the main cause of this spectacular increase is a progressive decline in the mortality rate in Asia that has followed the extension of modern medical services. Here, the population involved is so great (over 1,500 millions) that even a small reduction in the death-rate has notable consequences, and the United Nations' estimates attribute about 135 millions or 56 per cent. of the world population increase between 1950-57 to the Asian continent, the current rate of increase being given as 1.6 per cent. a year—the same as the figure for the world as a whole. Similiar trends have also resulted in the addition of nearly 50 millions since 1950 to the population of Latin America and Africa which are also characterized by predominently rural communities.

There is every indication that these trends will continue and that in Asia, Africa and Latin America as a whole mortality rates resulting from disease will be reduced more quickly than birth-rates are likely to fall, at least for the next two or three generations. Thus we appear to be on the threshold of a phase of population growth unprecedented in the world's history. Nothing more than a continuance of present growth would lead to a doubling of the present world population to reach 5,500 millions by the end of the century, and projections on a purely demographic basis —that is, neglecting economic factors or military disasters—indicate that this figure could be exceeded. At the same time, the geographical distribution pattern of world population is being constantly modified.

In part, population increase since the war has been accompanied by increased food production. In the western world as a whole, standards of living and nutrition are undoubtedly higher than they were in the 'thirties, and it is a remarkable tribute to technical progress in western rural industries that the rising demand has been supplied by a progressively diminishing rural labour force. To some extent, also, this increased rural output has contributed to urgent needs in various parts of eastern and southern Europe, Asia and Africa, not least as a result of American and Colombo Plan programmes of economic aid.

Statistics published by United Nations also indicate that the larger Asian nations

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have been able to achieve substantial increases in rice production though the effectiveness of this has been minimized by decreased output from the traditional rice exporting areas of Burma and Viet Nam:—

TABLE 1.

Average annual rice production

	1934-38	1954-56
	Million metric tons	
China	50.476	77.118
India	32.309	40.394
Japan	11.501	13.430
Indonesia	6.529	11.464
Rice Exporters		
Burma	6.971	6.047
Viet Nam	5.500	2.875
Totals	113.286	151.328

Source: United Nations' *Statistical Yearbook*, 1957, page 84.

These figures suggest an average annual increase of some two million tons of rice over the past 20 years and even though cultivation of other grains and vegetables has also increased one would hardly expect any amelioration of living standards, bearing in mind something of the order of a 250 million population increase for this area over the same period.

In India, the situation is particularly critical. The Report of the Planning Commission published in New Delhi in 1950 showed that the cultivated area per head of population in India had declined from the already low figure of 0.9 acre in 1911 to 0.6 acre in 1950. At the same time, in consequence of the establishment of new political regimes in Burma and Indo-China, rice imports have been roughly halved between 1937-39 (1.54 million tons annually) and 1951 (0.75 million tons). As early as 1944, the Nutrition Advisory Committee of the Indian Research Fund Association stated that to provide an adequate dietary by *Indian* standards, a five-fold consumption of fats and oil seeds, a four-fold consumption of vegetables, an eight-fold consumption of fish and meat and a doubling of milk consumption were necessary. This takes no account of the addition of some 4½ million every year to the Indian popution. Sir John Russell (1954) has estimated that "even to maintain the present low standards of nutrition in India about 32 million acres of land would need to be added to the cultivated area in the next ten years, or alternatively the output per acre increased by 15 per cent., or some 12 million additional acres brought under irrigation." The problem is the more intractable too because as British experience in India has shown, the most significant result of major efforts to increase food production is a lowering of the death rate and further acceleration of population growth.

Nor is India alone in this dilemma of food scarcity combined with a rapidly increasing population. Similar conditions obtain in Java, Pakistan and many parts of rural China. Essential food imports into Japan are being maintained precariously by means of a vulnerable export trade in manufactured goods. Parts of southern Europe and the West Indies support tightly packed rural communities at near-subsistence standards. Viewed in this light, the prospects for the future would not seem encouraging. Are the advances in the application of medical knowledge to be defeated by the old Malthusian bogy of starvation? Must we believe, as William Vogt has so eloquently urged in *The Road to Survival*, that "the curves of population and the means of survival have long since crossed . . . It is obvious that, fifty years hence, the world cannot support 3,000 million people at any but coolie standards for most of them"?

Basically the most crucial factor in the situation is land, for mankind still derives nearly all his food from the products of the soil. Less than 1 per cent. comes from the sea. Yet only 9 per cent. of the earth's land surface is cultivated with another 16 per cent. in use of varying efficiency and intensity as permanent pasture. The cultivated 9 per cent. amounts to 3,039 million acres and it need hardly be said that estimates for the maximum potential of cultivable acreage range over wide limits. As long ago as 1930, Professor C. B.

Fawcett—a British geographer of standing —suggested a figure of about 11,000 million acres (Fawcett 1930). More recent estimates have tended to raise this figure in consequence of new techniques for farming high latitude areas with very short growing seasons and for equatorial lowlands with highly leached soils. Thus Dr. E. W. Zimmermann (1951) an American economist, estimated 13,400 million acres as a total figure, Dr. H. L. Shantz (1942) has specified 15,600 million acres and Mr. Colin Clark (1957), one of the bolder economic prophets, has computed 15,200 million acres.

It may perhaps be argued that these estimates are of only academic interest, that the fertility of much of the land included in them is problematical, that difficult and expensive land clearance, drainage, irrigation and fertilization would be necessary and that remoteness from transport facilities and markets would be likely to delay their utilization. Even so, the figures are worth quoting as indicative of a fairly wide range of opinion that the world's arable land can ultimately be more than trebled. And if we choose to limit our attention to the more cautious pronouncements of the land utilization experts in respect of a shorter term objective we find a good deal of support for Dr. O. E. Baker's view that land "physically suitable for crops" could be extended in the foreseeable future by 1,200 to 1,900 million acres (Baker, 1948). R. M. Salter and C. E. Kellogg, working independently since the war, quote a comparable figure of 1,300 million acres, the former specifying that the potential additional acreage would include 900 million in S. America and Africa, 300 million in the northern part of the northern hemisphere (mainly in North America and the U.S.S.R.) and 100 million in the islands to the south of Asia (quoted in United Nations, 1953).

From all these expert opinions, I believe that one is justified in assuming that, for the present century at least, there should be no shortage of land. Additionally, yields from existing farmland have been augmented in spectacular fashion in recent years in consequence of achievements in agricultural and soil science and plant and animal genetics on the one hand and of economic incentive on the other. To take random examples, Australian wheat yields have risen from an average of 8.21 bushels per acre for the 1880's to 16.4 for 1947-1954. United States' production of wheat and beef was nearly doubled between the late 1930's and the late 1940's (from 750 to 1,300 million bushels and 5½ to 10 million cwt respectively), without anything like a corresponding increase of farmland. Nor have these achievements been limited to the New World. Danish wheat yields increased from 3040 kilograms per hectare in 1934/38 to 3710 in 1948/53 and the Netherland's milk yields from 7790 lb per cow in 1939 to 8316 in 1950. Coming back to Australia, there can be no purely technical reason why production of beef and sugar cane could not be doubled and rice production increased six or eight-fold given a suitable economic climate, and a similar kind of situation exists in many other southern lands.

For the foreseeable future, therefore, and for the world as a whole, there is neither a land shortage nor is there generally the spectre of diminishing returns from food producing land. The critical element in the situation is economic, though it has social and political repercussions, namely, how to provide food for overcrowded rural communities which are in process of becoming more overcrowded yet which can neither grow enough food for local needs nor afford to buy it from elsewhere. In the main, also, this is a problem that primarily concerns Asia though as we have seen the situation is repeated on a smaller scale in parts of the West Indies, southern Europe and Africa.

There is no universal panacea or comprehensive solution yet in sight, but the most promising lines of action appear to be fivefold:—

Firstly, there must be some re-distribution of population. This need not be on an international scale and few people would envisage large scale migration on an intercontinental scale. There are still substantial tracts of country in India and China that

could be brought under cultivation, while vast areas in Indonesia, Burma, Siam and Indo-China await development. Transfers of population would be difficult enough, but the main obstacle is lack of capital. Clearance, drainage and preparation of land in areas remote from roads and railways, the provision of water, the construction of buildings on a scale that would create a significant impact, would involve capital expenditure beyond the resources of most of the countries concerned. American and Colombo plan economic aid—welcome and valuable as it has been—has not been on the requisite scale nor has it been concentrated sufficiently on big schemes.

Secondly, an increased measure of urbanization in Asian lands seems essential. It is frequently pointed out that no country specializing in agricultural production for home consumption has attained a high living standard. Industrialization, even the extension of the cottage industries so persistently advocated for India by Gandhi, contributes to the development of agriculture, both directly through the production of fertilizers or agricultural equipment and indirectly through the provision of a larger market for cash crops which would provide an income for many farmers who previously had no alternative to living almost exclusively off the produce of their own land. Factory industrialization in countries such as India and China creates new employment for wage earners who in turn acquire increased purchasing power and make greater demands on factory production. This snowballing effect, however, cannot be achieved without the establishment of new food producing areas or without an assured import trade in the necessary foodstuffs at prices that the industrial workers can afford. Also, to be effective in raising living standards the industrialization must be both rapid and substantial. It has been calculated (United Nations, 1953) that "if India's population and her manufacturing output should both continue to rise at the average rates which prevailed during the period 1896-1900 to 1936-38, some 90 years would be required for the *per capita* output in manufacturing to reach the mark achieved in Japan in 1936-38 . . . meanwhile the population, already very dense, would increase by four-fifths."

Thirdly, the creation of new farmland on a large scale is immensely expensive and far less difficult in the highly capitalized western countries than for Oriental lands. This implies a strong moral obligation on the part of western countries to produce food in bulk for overcrowded areas. And surely it is not beyond the limits of present-day technological achievement for this is to be done and food supplied at prices acceptable to Oriental markets? In this connection the Humpty Doo experiment will be watched with close interest.

Fourthly, perhaps the biggest problem of all, is how to hasten a lowering of birth rates commensurate with the current reduction in the death rate. If public opinion in the extra-western world cannot be induced to accept some form of birth control, it is hard to see how, in the twentieth century at least, the supply of food can overtake the demand for it. And finally, it must be reiterated that increasing production in itself will not necessarily raise living standards. Some countries have benefited from a large volume of incoming capital and have seen their output expand but very often only a tiny minority of their population has experienced any greater prosperity. New technology, new capitalization can be widely beneficial only if accompanied by social change designed to further the interest of a growing proportion of the population.

For humanity to survive and prosper therefore, technological and scientific advances must be matched by economic and social reforms, the significance of which overspread the national interests and influence of individual countries. The design for international co-operation must provide for an increased flow of trade between east and west and for a more effective flow of capital across national borders, and these economic advances must be achieved in such a way that extension of economic hinterlands is not conceived in terms of extended political control. We can only

hope that progress along these lines can be achieved quickly enough to avert an international catastrophe.

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Thesis Summary

The Present and Potential Productivity from Pastures in the Irrigation Districts of North Western Victoria

The area under consideration consists of the Torrumbarry Irrigation System and the adjoining North-western districts of the Goulburn System.

The term "productivity from pastures" is defined as the total quantity of stock nutrients which are conveyed to livestock from all pastures.

Pastoral productivity in this area can be increased (above the level of the early '50s.) by:—

1. Increasing water allocations to the irrigation districts concerned.
2. Delivering water to farms with greater efficiency.
3. Using water more efficiently on farms,
4. Combating salt.
5. Establishing more improved pastures.
6. Increasing the use of fertilisers, principally phosphatic and nitrogenous.
7. Improving pasture utilisation methods.
8. Installing better drainage facilities.
9. Controlling insect pests, weeds and plant diseases.
10. Maintaining control of the rabbit.

Each of these avenues of improvement is discussed in some detail, the sections on water use on farms, salt, and fertilisers receiving greatest attention. Data relating to these three sections has been collected from the experimental plots of the Victorian Department of Agriculture.

It is concluded that a thirty-fold increase in the stock nutrients conveyed to livestock from pastures in this area appears technically possible through attention to the ten aspects of pasture production listed above, but excluding techniques never likely to become economical such as provision of artificial light or artificially raising atmospheric carbon dioxide levels.

Throughout the thesis the present methods of pasture production are described and a Land-Use Survey of the Parish of Macorna included in the appendix provides further information on the existing agriculture of the area.

Whilst the methods of pasture production used over large areas can never hope to come even close to technical perfection, a great advancement in the efficiency of production should occur during the next 10-20 years.

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WOOL IN THE WORLD MARKET AND IN AUSTRALIA'S ECONOMY

R. B. McMILLAN

Australia in the World of Wool

Australia occupies a dominant position in the world wool industry. The sheep population of close to 150 million (149,319,000 at March 31, 1958) is 16 per cent. of the world's sheep population. These sheep produce 29 per cent. of the world's wool, 37 per cent. of the world's apparel wool and 53 per cent. of the world's merino wool. Also, Australia's wool exports represent about 45 per cent. of all the wool entering international trade. In each of these respects Australia is by far the most important country in the world.

In recent seasons a clip of from 4 to 5 million bales has been marketed each year, and, depending on quantity and price, has realised between £300 million and £500 million. At present levels of production, every penny difference in the average price at auction means a difference of £6 million in the wool cheque.

A wool cheque of this size is a factor of major importance to the economy. It is channelled back to the 100,000 woolgrowers through wool selling brokers, and any reduction in it has its first and most direct effect on these growers and their financial position. But the chain reaction on the community in general is also quite substantial. All those firms and individuals providing the goods and services which go into the production of wool are also affected directly; these include shearers, farm contractors, pastoral companies, machinery and equipment suppliers, the transport industry, and in fact all those providing the living requirements of 100,000 woolgrowers, their employees, and their families.

A fall in the wool cheque also has a serious effect on the liquidity of the banking system and its ability to lend to industry generally. The national finances, too, are affected through the fall in national income and the budget thus suffers from the resultant fall in income tax receipts.

Wool as an Earner of Export Income

Some 92½ per cent. of the wool produced in Australia is exported, most of it in the greasy state or on sheepskins, but some as scoured or carbonised wool, while there is also a growing trade in wool tops, noils and wastes. With the addition of processing costs and charges to f.o.b., and also taking in certain wools that do not pass through the auction system, the total earnings of oversea funds from wool exports usually slightly exceed the realisations at auctions. For instance, total realisations at auction for 1958-59 are expected to be in the vicinity of £290 million, yet the value of all wool exports—including raw wool, tops, noils, wastes and sheepskins—may be about £320 million. In spite of the fact that

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the clip has been of near-record size, these figures are the lowest since 1949-50, because of the depressed state of wool prices over most of the season.

Wool's export earnings, in spite of the development of trade in other commodities, still account for 50 per cent. of the total merchandise exports. A setback in the earnings from wool exports means a setback to our overseas reserves and our ability to maintain the flow of imports required by an expanding economy. The importance of this at the present stage of Australia's development cannot be too strongly stressed. The immediate reaction of many is to say that Australians are over-dependent on wool, and that something must be done about it, by diversifying our exports and our economy. That is a worthy aim; but it is also a fact that, no matter which way the economy is studied, such diversification will be difficult to achieve.

Manufacturing has so far contributed relatively little to our exports, and though it is showing some encouraging signs of development, the cost structure in this country makes it an unlikely source of any substantial gains in the near future. Looking to the other primary industries, they may be examined one by one, and it will be found that almost all are faced with prospects of shrinking rather than expanding markets. This may sound a sweeping generalisation, but this is only a restatement of the results of recent detailed studies by experts in these fields. Their conclusions have been that only minor export gains are in prospect in the near future except for wool, which alone holds out the prospect of worthwhile expansion.

Even assuming that it is a mistaken view to discount the prospects of early diversification, I believe that diversification achieves nothing worth while if it involves retarding successful existing industries for the sake of encouraging others less likely to succeed. It should rather come about by the growth of good new industries alongside continued growth of good old ones. My belief is that we can, and therefore must, continue to expand our production of wool, as a matter of national importance, and as a continuing foundation for our current economic development.

The Australian Wool Textile Industry

In spite of the fact that most of the clip is exported, the remaining 7½ per cent. which passes through local mills is sufficiently large to place Australia in the top ten wool consuming countries of the world, consuming between 110 and 120 million lb greasy a year, worth some £25 to £30 million to growers each year at recent price levels. Part of this industry supplies a rapidly growing export trade in wool tops to Eastern countries, but the major share goes to supplying the local market for wool goods. The industry provides employment for 22,000 persons of whom about 60 per cent. are females. Per capita consumption of wool by Australians, which has recently been around 7½ lb clean (about 13 lb greasy) per head, is substantially higher than in most other countries.

Incidentally, a home consumption base of only 7½ per cent. of the total places wool in a vastly different category from our other main rural exports, and is an obvious explanation for the absence of any home consumption price scheme for wool. The market for Australian wool is, in a very real sense, the world market.

The Nature of Our Wool Exports

Of the exports, some 75 per cent. are in the greasy shorn state; the balance is made up of scoured and carbonised wool (which are both considered as still being in the raw state), as well as tops, noils and waste (which are products and by-products of manufacture); in addition, there is a fairly steady trade in sheepskins carrying wool.

Why is it that the major part of these exports is in the form of greasy wool? The first reason for this lies in the nature of wool itself, in that it is not by any means a commodity of uniform characteristics. Wool is in fact one of the most diverse of all commodities entering world trade. It can even be argued that every bale produced in this country is different from every other bale in some respect; for instance, there are differences in fibre diameter, length, colour, presence

or absence of burr, uniformity of growth, yield, and so on. These characteristics and the differences between them are obvious to a trained wool man, and are most clearly apparent to him when the wool is in the greasy state. Much of the character of wool is masked by the scouring process, in which the grease and other impurities are washed from the wool and its staple formation is at the same time disturbed. The art of wool textile manufacture lies in the ability of processors to select and blend the range of raw wools to produce the type of product desired, and this selection and blending can be done best by the processor himself at the point of manufacture, if possible in the greasy state, by selecting and handling the wools which he recognises as being capable of producing the desired results. Therefore, most countries with a highly developed wool-processing industry prefer to draw their supplies of wool in greasy form.

There is also a further reason, in that traditionally the development of textile industries seems to have taken the form of the establishment of the later stages of processing first. In other words, a developing economy will establish first a weaving industry, then spinning, then topmaking, scouring and carbonising, carrying backwards its capacity one step closer to the raw product at each stage. It follows from this that the more developed a country's textile industry is, the greater will be the share of its purchases of wool in the raw state.

Thus, while there are relatively undeveloped economies, mainly in East and South-East Asia, providing Australia with markets for wool tops and for scoured and carbonised wool, the more advanced economies of Europe, Japan and North America provide the main markets for our greasy wool. Actually, the range of countries to which Australia is an exporter is growing steadily each season, and it is to these newer markets that we must continually look for fresh markets for the semi-processed product. At the same time there will be a progressive shift on their part towards purchase of greasy wool. Therefore, it would seem wise for Australia to accept that the continued expansion of the clip will mean continued growth of greasy wool exports rather than of the semi-manufactures.

Prospects for the Future

The unsatisfactory levels of wool prices throughout most of 1958-59 have given rise to fears that wool may have entered into a phase of more-or-less permanent depression. The renewed rise in the size of the clip, with a possibility of reaching five million bales for the first time in 1959-60, has reinforced the fears of some that wool may have been overproduced. There are others who point out that wool's share of the world textile fibre market has shrunk from 13 per cent. in the immediate pre-war years to 9 per cent. last year, with the inference that wool is losing its relative appeal.

I believe these fears about wool to be quite groundless. The facts are that, since the war the world demand for fibres has increased considerably faster than the rate at which wool production could be increased. In fact, aided by disposal of the war-time stockpiles, world consumption of wool has actually exceeded production in most years, and its general trend has been steadily upwards. Last year was an exception, but it must be remembered that wool was not alone in 1958, as the other apparel fibres suffered similarly depressed conditions also.

It is as well to remember that we have always managed to dispose of the whole of our clip, and that there has been no significant carryover any season since the war. I am quite confident that the large 1959-60 clip will be just as fully absorbed, and that whatever we can produce in the foreseeable future will be fully taken up by expansion in the world's economy and by demand from new consuming countries not hitherto accustomed to wool. Perhaps it would be foolish to expect prices again to reach their 1953 and 1956-57 levels, since the alternative use of other fibres now tends to place a virtual ceiling on wool prices. But with continued advances in productive efficiency wool producers should be able to look forward with confidence to the future.

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Articles

GETTING RESEARCH RESULTS TO WOOL GROWERS

D. B. WILLIAMS

Many alternative approaches come to mind when one faces up to the problem of communication in the wool industry. We can't go far without some knowledge of the social structure of the rural community; then there are the different methods of communication, ranging from mass media such as the press and radio to consultants who advise individual woolgrowers in detail about their management problems; then, too, we should understand the different forms in which research findings are expressed, from the high-powered scientific paper through semi-technical leaflets and journals to the press release by local agricultural advisers.

All of these problems hold a fascination for those interested in getting research results applied in practice. In Australia, they are relatively unexplored fields. Together, they are an opportunity for the scholarship, the inspiration, and the determination which, together, will create a concept of extension, adapted to the Australian environment.

But I shall refer only in passing to these problems. The present purpose will be somewhat more pedestrian—to explore the institutional structure of Australian extension services.

BY WAY OF INTRODUCTION

Our extension services depend for success on four different features which will be discussed in this review.

- An adequate flow of new research results, expressed in such a way that they can be used in practice.
- Proper participation by the rural people, at the national level where research and extension policies are defined, through to the grass roots where they are implemented.
- Career opportunities for extension officers which provide for the full development and expression of individual abilities throughout their whole working life.
- Freedom to pursue the objectives of extension, even though the departments providing the extension services have other responsibilities, such as inspection and control work of various kinds.

This leads me to say that at the level of government, preoccupation with the Commonwealth-State relations has blinded us to the fact that extension is a many-splendoured thing. Many different disciplines need to be integrated to establish a science of Extension, and many different groups engaged in different government services and in commerce can play a role in communicating research results to farmers.

Because extension work among farmers is a many-splendoured thing, fulfilment alternates with frustration in the style of a grande affaire.

One implicit assumption, which I don't propose to argue further, is that it is an accepted function of government to provide educational

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services. Furthermore, these services should include efforts to ensure that the farming community (no less and no more than other sectors) should be able to get access to new knowledge which may enable them to change their production techniques.

Some corollaries which emerge are not so clear cut—especially the problem of who should finance this education process. Another problem now looming large is the extent to which these educational services should encourage acceptance of programmes thought by the government of the time to be "in the national interest". For example, in the United States, much of the emphasis in extension work is now shifting to problems of adjustment on a national scale and to the role of new technology in contributing to adjustments which accompany economic growth. In Australia, these two problems underlie many of the difficulties being encountered in administering the different research funds collected by levies on wool, wheat, and dairy produce.

FULFILMENT

We shall have enough of frustration later. To avoid a distorted view we need to pause and record the very great advances which the wool industry has achieved in recent years, which reflect the widespread application of the results of research in farming practice.

Progress in the Wool Industry

There are many measures of this progress. Sheep numbers are now up to 149 million, having climbed there from 123 million in 1953, and from 110 million pre-war. Meanwhile the wool clip per head has also risen. By any standard—output per man, areas under improved pasture, amount of fertilizer used, degree of mechanisation, amount of fodder conservation, adequacy of disease and pest control measures, there have been very great advances in the last decade.

Even in the eight years since 1950-51, the amount of superphosphate used on pastures throughout Australia has almost doubled; the area of sown pastures has doubled; tractor numbers on farms have almost doubled, while hay production has increased by about 50 per cent. All this, and more, has been achieved by a farm work force which has remained virtually stable. Most of these advances have depended on new research results, together with savings from earnings sufficient to enable new investment to occur. Since two out of five rural holdings in Australia carry sheep, these measures of change mirror the great advances being made in the sheep industry. Indeed the sheep industry perhaps has been the most adaptable of all in taking advantage of new opportunities to change.

But, we should note in passing, these increases in gross output alone do not show that our extension services are making their full contribution to development. More and more attention needs to be paid to the effects on efficiency of new techniques based on scientific advances. Furthermore, setting the wool industry aside for the moment, there are large sectors of our rural industries, and some isolated geographic pockets, which have remained relatively static during the last decade, when so many new developments have virtually transformed the Australian countryside. A well-rounded extension programme would devote attention to economic and social problems such as these, as well as to those involved in getting new research results into practice.

Thus, any discontent with the present position is purely relative, and indeed to a large extent ignores the perspective one gains by viewing the present position in its historical setting. But such discontent should not mask the fact that in the last decade the wool industry has not only taken very full advantage of good seasons and, until recently, good prices, but of new research results as well. Somehow, some way, research results are getting through to woolgrowers.

Who is doing this? Is it a haphazard process? What changes are occurring in the provision of services by governments and by commercial firms to the rural people? How do these changes influence the transfer of new knowledge?

The Australian Rural Community

Without probing too deeply, we should note in passing some of the more important features

of our rural society. These features determine the nature of communication channels, and influence the acceptance of new knowledge and new ideas to which the community is exposed.

The Australian rural community enjoys a high level of literacy, with well-developed transport and communication services; our farming system is founded largely on commercial farming based on specialized production techniques. For the most part, our farmers seek to improve their present and future position as individuals, and as members of a family group.

These characteristics contrast to a greater or lesser degree with those of more primitive communities where literacy levels are lower, communications undeveloped, and where methods of production are influenced by non-commercial motives and especially by traditional links with the past. The influence of wider family or social groups, which are so often motivated by adherence to traditions and which are so sensitive to the links with the past, does not appear to be so strong in Australia as in many overseas countries.

Not that we are free from the influence of taboos and the like in our rural society. There are social strata which influence the flow of information, and which restrict the range of things which are socially acceptable.

Several studies have been made to explore the influence of the social structure of the rural community, and the way in which the results of research flow to graziers (e.g. Emery, Oeser and Tully 1958; Fallding 1957,1958.)

We should also note the very great influence of government activity in Australian country areas. Federal, state or local governments nowadays control or influence in one way or another most of the significant decisions made by farmers; they administer rural awards; they regulate land tenure, transport, stock routes, weed and pest control, and they provide a whole host of services ranging from supplies of pure certified seed, pedigree stock and telephones, to rabbit destruction and herd-testing facilities. The provision of educational services is often intermingled with other government activities, such as inspection and regulatory work.

Sources of Information

The kind of problems about which a woolgrower may seek advice include, for example:

- How to improve rabbit control on his property.
- The best way to pass on his farm to his son.
- Whether aerial topdressing pays better than ground machines.
- How to finance the purchase of a tractor, and especially whether he should use hire-purchase.
- How to control a pest outbreak, e.g. blowflies.
- Whether he should alter the type of sheep so as to change the emphasis from wool to more fat lamb production.

This list reveals two most significant points in understanding the problem of communicating information which emerges from scientific research programmes.

First, woolgrowers don't want scientific research results for their own sake; woolgrowers want to solve their own problems and they are not particularly interested in using new methods which don't contribute in some way to their problems. It therefore becomes part of the extension problem to identify these goals which motivate woolgrowers, and see how new research results can help woolgrowers to achieve them. It then remains to express the research results in appropriate terms, tailored to the needs of farmers (Williams 1959).

Second, agencies other than governments play a significant role in transmitting information to woolgrowers. Machinery firms, seed and fertilizer firms, banks, land and stock agents, income tax agents, and other consultants all form part of a system which provides new information. Their role is important not only because they can actively provide information for woolgrowers. They can also influence the prevailing climate of opinion about new methods of production. They can also help farmers to get access to knowledge which may help them to make management decisions.

An increasing educational effort is being made by private firms as part of their technical services associated with selling campaigns.

Pre-war there were about 30 agricultural scientists employed in industry. Today there are some 180, many of whom are engaged in providing technical services to the rural community. New films, field days, new publications and other educational activities all mean that new minds, new approaches, and new skills are being marshalled for the task of handing information on to farmers. Furthermore, as more specialised production methods are developed, there is more and more scope for off-farm purchases of production services of one kind or another—thus changing the role of different participants in the extension process.

Private firms must be expected to become more and more important in advisory work. Properly administered, they need not necessarily be competitive with government agencies.

What is Extension?

Extension work among farmers has been so highly developed in the United States that it has become part and parcel of the accepted way of life. A recent publication (U.S.D.A. 1958) which summarizes the concept of extension in that country, refers to Extension's function as education, not in the abstract, "but education for action. It is education of an informal and distinct type. It is education directed to helping people solve the various problems which they encounter from day to day in agriculture, home economics, and related subjects."

"In performing its function, Extension operates informally, in line with the most important local needs and opportunities, and with respect to both short-time and long-time matters of concern. It joins with people in helping them to:

- Identify their needs, problems, and opportunities.
- Study their resources.
- Become familiar with specific methods of overcoming problems.
- Analyze alternative solutions to their problems where alternatives exist.
- Arrive at the most promising course of action in light of their own desire, resources, and abilities.

In so doing, Extension workers bring to people the pertinent research information available; interpret and demonstrate its application to the immediate situations involved; and, through the most effective methods known, encourage the application of such research in solving problems. At all times, the widespread participation of the people is stressed in both planning and conducting these informal educational efforts."

The essence of the extension educational system is to help people to help themselves. There is a flow of information from scientists to rural people. But the use of this information depends on a system of "feed back" of problems which remain unsolved, and of problems which emerge in practice, when the results of research are used to change farm practices. Furthermore, constant effort is needed to show how the new information solves the problems being faced by woolgrowers.

Woolgrowers then need not only access to new knowledge. They also need help and guidance in deciding for themselves how this new knowledge can enable them to improve their well-being—in accordance with their own ideas of what constitutes improved well-being.

What is Liaison?

The extension process should not be conceived merely as the last point of contact between the farmer and the government officer conveying information to him. It is far more than that. It involves the whole complex of interchange of information between extension workers and scientists engaged in both fundamental and applied research, with assistance from firms engaged in commerce.

In practice, research results are constantly reaching the rural community through such media as newspapers, radio, journals, magazines, etc. These break-throughs may occur at all stages along the extension spectrum from fundamental research to its application in practice. Furthermore, some of those contributing to these break-throughs by the use of media for mass communication, (i.e. C.S.I.R.O. and University personnel, research officers in State Departments, and employees

of firms in private industry) may not always be conscious of the extension implications of the information they are conveying. It is one of the responsibilities of liaison officers to watch for, and even anticipate these breakthroughs, so as to ensure that the extension officer is provided with the additional information needed to assist him to assess the importance of the research result in his own particular area.

Back of the extension worker, liaison work helps to identify research findings which have use as a basis for new farm practices. The Agricultural Research Liaison Section of C.S.I.R.O. has been created to attempt to express and interpret research results in terms which help extension officers to recognise their practical significance and limitations; to encourage freer interchange of research findings between research and extension personnel; and to identify problems needing more research.

These goals are being achieved by publications such as "Rural Research in C.S.I.R.O.", by liaison work on both an informal and formal basis (e.g. the Southern Tablelands Regional Study) and by research in the field of the use and communication of scientific research findings.

FRUSTRATION

In other countries extension work has arisen from and followed the growth of research services. Research findings, of use to rural people, enabled a favourable political environment to evolve, which was needed so that adequate finance could be made available for extension work.

In Australia the relatively low status of extension work within the State political scene, rather than any lack of insight by the extension authorities themselves, is the reason for the relatively undeveloped state of our government extension services, compared with research work. In spite of these handicaps extension officers have made contributions which are measured by the widespread adoption of new methods of production. Their efforts have prepared the way for more progress. There is a mounting belief, which now needs to be backed by action, that the time is ripe to provide much more money for extension services, as the value of research findings becomes more evident. For example, the late Sir Ian Clunies Ross, commenting on the Institute's report *Agricultural Scientists in Australia,* said:

> More money must be made available to the State agricultural services if full use is to be made of research findings. Increased funds for research are becoming available from levies on wool, wheat and dairy products, and very probably on beef. These funds are matched £ for £ by the Commonwealth. It is essential that expenditure on extension services should more than keep pace with expenditure on research if the rural community is to receive the maximum benefits from research.

Extension Services in Australia

In Australia, the Federal System leaves responsibility for agricultural production in the hands of the states, and each state has a State Department of Agriculture which administers extension services for farmers.

There are very great differences between the states in the organisation of extension services for woolgrowers. But the general pattern in each State Department of Agriculture is that there is a Sheep Husbandry section, often a part of the Division of Animal Production. This Sheep Husbandry section conducts both research and extension work for the sheep industry, aided by other specialist officers such as the entomologist, who cooperate as required in research and extension problems. There is also in some states an Extension Division which is more or less responsible for all extension work among farmers. The relationship between the Extension Division and sheep and wool officers (and other specialists) varies between states. But the split between plant and animal work has hindered the effectiveness of each of the different divisions.

Thus a predominant feature of extension services is that they operate within a departmental structure in which they are combined with government administration and inspection work. Furthermore, there is a split of responsibilities and of specialised knowledge between different State Departments, e.g. Agriculture,

Lands, Conservation, State Banks. Departments being what they are, this has created barriers to thought and analysis of farmers' problems. Even within departments, the methods for cooperation between divisions are somewhat cumbersome — despite exceptions which rely on personal goodwill rather than on established procedures.

In the event, the extension services act on an out-going basis, tending to hand on to the rural community the contributions of specialists. Each of the specialist disciplines has a vital role to play, and indeed in the past the specialist has been the one who has broken the bottleneck to higher or more efficient production by overcoming such problems as a major disease or nutritional disorder. But while they must provide much of the basic data they cannot provide all the information in a form which makes it most useful to farmers.

The Cult of the Specialist

This reliance on subject matters specialists, called elsewhere the Fallacy of the Single Sciences (Williams 1958) may explain the comparative neglect of some vital problems, e.g. fodder conservation, soil fertility, bushfires, rabbits, and agricultural climatology. These are essentially problems beyond the confines of any one specialist. There have, of course, been efforts to overcome this emphasis on specialist disciplines within C.S.I.R.O., the universities and the Departments of Agriculture. But in the Departments of Agriculture, where the emphasis on applied problems makes the specialist cult least appropriate of all, the divisional structure has been too strong for this action to have resolved the main problem of breaking away from the narrow field of interest of the specialist.

Public Service Influences

Many characteristics of the extension services reflect their origin as part of the State Public Service. The Commonwealth-State financial relationships, together with the low political status of problems relating to the extension services in each state, have contributed quite a deal to the extraordinarily poor facilities available to many extension officers. The Institute's report *Agricultural Scientists in Australia,* 1959, highlights the unfavourable salaries available to agricultural scientists in the State Public Service compared with those in universities and C.S.I.R.O., where the bulk of research is undertaken.

Paper reports, administrative responsibilities, not to mention inspection work arising from the need to administer different Acts of Parliament, and poor facilities for work, are all part and parcel of the extension officer's life. Undue busyness with these responsibilities may threaten to destroy the initiative and zeal of the officers.

A measure of how these factors have influenced the position of extension officers is provided in the survey recently conducted by the Australian Institute of Agricultural Science in 1958, some results of which have been published in the Institute's report *Agricultural Scientists in Australia.* The survey included one question asking respondents to specify whether or not they were engaged in extension work, and if so, whether this work was a major part of their responsibilities. The Institute members, being graduates for the most part, do not represent the whole extension service. But at least they do constitute a significant part of it. The data refer to the position as at July 1, 1958. For this analysis, as for so much of the Institute's survey, I am indebted to Mr. N. Tyshing who, with Mr. J. Lenaghan and Mr. R. Farquhar, assisted in the planning and interpretation of the survey results.

Of the 864 respondents, (70 per cent. of questionnaires sent out) 32 were women and 57 were engaged in farming. The remaining 775 included 252 who did some extension work, distributed as follows:

193 were in State Departments of Agriculture

32 were in other State Government Departments

27 were employed in industry and Commonwealth Departments.

When the information about work responsibilities of the 225 officers in State Government services was analysed, the following picture emerged:

36 officers engaged in extension work full time, covering all subject matter fields, e.g., district agricultural officers;

15 officers engaged in extension work full time, but were specialists in particular subject matter fields, e.g., weeds specialist;

125 officers engaged in both extension and research;

49 officers engaged in both extension and administration.

Of the 51 officers engaged wholly on extension work, 48 had a Bachelor's degree and only 2 had a Master's degree; of the 174 who had other responsibilities as well, 16 had a Master's degree and 3 had a Doctorate.

It is notable that there are relatively few graduate officers engaged full time in extension work. Some explanation for this emerges when we compare the salaries of officers in State Departments of Agriculture with those in other employer categories, as set out in the Institute's report. The evidence bears out the point that officers have to accept other responsibilities as well as extension work in order to gain promotion.

The dominant influence of Public Service procedures is also reflected in the absence of career ranges and the need to move from position to position in order to follow promotion opportunities. The top salary paid to extension officers stationed in the country in New South Wales is just over £1800, except for about eight Regional Supervisors who are paid just over £2000. Promotion to higher salaries can only be obtained by moving to Head Office. Consequently the officers, as temporary residents in rural areas, are not al-

Graduate Extension Officers in State Government Services

Salaries and Age: July 1, 1958

Salary Range £ per annum	Number of officers in each group			
	Full Time Extension		Part Time Extension	
	General	Specialist	Plus Research	Plus Administration
Less than 1200	1	2	10	—
1200—1399	14	8	30	2
1400—1599	16	2	51	7
1600—1799	2	2	19	9
1800—1999	—	1	6	11
2000—2499	3	—	8	15
2500 or above	—	—	1	5
Average Salary	£1485	£1393	£1518	£1991
Age in Years				
20—24	6	5	16	—
25—29	10	4	39	3
30—34	9	4	37	12
35—39	5	—	17	6
40—44	1	—	5	2
45—49	2	—	8	8
50 or above	3	2	3	18
Average Age	33 yrs.	30 yrs.	32 yrs.	43 yrs.

ways an integral part of the rural community. For this and other reasons they face enormous difficulties in establishing effective *rapport* with the rural people. These other reasons include, in some cases, an implicit acceptance of the idea that successful extension work depends on being "one of the boys" rather than an influential adviser, with a professional status comparable with the local doctor, dentist, solicitor, or accountant.

No Formal Discipline of Extension

As yet, there is no formal discipline of extension at University level in Australia, especially at postgraduate level. We see glimmers of this in some short courses in our Faculties of Agriculture, and interest in the extension process is emerging at different Universities. The absence of graduate courses has meant that the status of extension work has been lower than that of research. Lack of work in this field by social scientists, and difficulties associated with research which involves a review of the work of government agencies has hindered formal studies of extension procedures. My own view is that the discipline of Extension should be built up at the graduate level, rather than by undue attention to it at the undergraduate level, to the great detriment of training in the basic sciences. Our agricultural science courses are vocational and empirical enough as they are—spare us any further widening of the range of subjects covered that could prevent the undergraduates being trained as scientists, to analyse and to think.

To Sum Up

Thus, in Australia our extension services, suffering as they have for so long from financial malnutrition, have not yet become part of a specialised discipline which embraces both biological and social sciences and provides satisfying professional careers for graduate extension officers.

For the most part there is little active participation by the farming community in planning and carrying out advisory work, though advisory committees, at the grass roots level, are now functioning in several of the states. Rather, our extension services are part of an arm of the state governments, administering their programmes and their policies. Far less is there cooperative effort to identify the rural community's goals and to solve the problems which clutter up the achievement of those goals. Finally, the system does not provide for a marriage of policy aims defined by our national leaders with the everyday management decisions made by farmers.

HOPE FOR THE FUTURE

But we need not, and should not, despair. There is gradual improvement and change evident in Australian extension services.

Supporting Services

Beyond government, the role of commercial firms is becoming more and more important. New techniques are developed which require more and more off-farm service, in the form of advice about fertilisers, chemicals for pest control, machinery and the like. Many of these new changes mean that there are new opportunities for contract services, such as by the use of aeroplanes for crop spraying and top-dressing. As these new forms of off-farm advice or contract services are developed, changes occur in the ways by which new methods of production can be introduced on farms. There are many opportunities to use these commercial firms, stock and insurance agents, and bankers, to contribute, each in a different way appropriate to its own activities, to the task of making research findings available to the rural people. But the government extension services will continue to be of overwhelming importance.

The need for individual advice about management problems is now more widely recognized, and groups of farmers are together forming clubs to employ full time consultants. This has occurred at Bombala, N.S.W., and Brunswick, W.A., and new clubs are being formed in other places too. Independent consultants, available to advise farmers on a fee basis, are also becoming established. My own view is that there will be a very great expansion of this kind of consultant service in the future, especially the independent consultant.

Finally, the role of Primary Producer organizations in Australia is of growing significance in extension work. These have already had great effects on research services in the wool and wheat industries. Primary producers nowadays finance some of the research schemes by taxes levied on wool, wheat and dairy products, and their organizations are becoming increasingly active in policy making and in the administration of funds available from these levies.

For our present purposes the significant thing is that pressure is mounting from these organizations to ensure that research findings are made available quickly and effectively to the rural community. Their influence as a forum and mouthpiece for our rural people must be expected to increase in the future, and significant changes in the nature of our extension services could well be sparked off by their activities.

Government Services

Within governments, more and more attention is being given to extension work. More money is being made available by the states, supplemented by such sources as the Commonwealth Extension Services Grant and the Dairy Extension Grant provided by the Commonwealth for the State Departments of Agriculture. These grants have provided opportunities for improved facilities, better publications, overseas study by experienced extension officers and freer interchange of views and experience between officers in the different States.

Conclusion

Let us now reiterate the four features referred to in the Introduction, which determine the success of extension services.

First, there is a need for an adequate flow of research results, expressed in a way which enables them to be used in practice. That is to say, in Australia, we need not only to continue our research programmes. We should also support them by liaison work and economic analysis which expresses the results in ways which help farmers to overcome their day-to-day management problems.

A second feature of extension services is the relationships which are established with the rural people. This is a complex problem, but much more can be done at both the national and township level. One obvious implication in Australia is that we need to pay more attention to the effects on our research and extension services, of the increased tempo in our research programmes arising from the levies on wool, wheat and dairy products. These levies have meant that there has been more active participation by producers in discussions about research programmes—and ways by which they can help the man on the land. This new environment, in which primary producers are participating more actively in research planning and administration, is one which may enable us first to achieve and then to maintain a better balance between fundamental research, applied research, and extension work.

Thirdly, the importance of career opportunities for extension officers is stressed. This is the major immediate problem. We should face up to the need to create opportunities in our extension services, and to provide training at our universities, which enables extension officers to achieve a professional status comparable with that of research personnel. To a large extent, this depends upon provision of more money for extension services. But it depends also on developing more graduate training and in-service training as well.

Fourthly, reference was made to the need for extension services to have freedom to pursue their extension objectives, and for the separate identification of extension services when departments have other administrative and inspection responsibilities as well. Perhaps the ultimate solution may be a separate statutory authority responsible for all extension work within each State. But we are a long way yet from such a situation, because of the established status and spheres of influence of different departments, and even of divisions within departments, within each State. The problem of regathering the responsibility for many phases of extension work within one agency would be enormous.

All this, of course, is an idealist's conception of what might be. But, by setting out the features of our extension services in this way, one can appreciate more fully the tremendous task facing our colleagues engaged in extension. One is also moved to admire the devotion to their work which has kept them in the field under conditions and with facilities which compare so unfavourably with those of their professional colleagues engaged in research.

These extension officers, immersed in their day-to-day work, drawing on their professional training and experience and rubbing shoulders with other groups who provide services for farmers, alternating as they do between frustration and fulfilment, know full well that extension is, indeed, a many-splendoured thing.

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Thesis Summary

Physical Properties of Some Victorian Soils

The thesis is divided into two parts. In the first some physical properties of eleven representative Victorian soils are given. The properties studied include pore size distribution, water stable aggregation and moisture contents at various pH values, which give a measure of various aspects of structure and moisture regime. The core sampler used for taking undisturbed samples is described, as are the laboratory methods for determination of the physical properties. To aid in the interpretation of the results, a table of standards for each physical property is given. The measurement of structure and soil water relations is discussed and the results related to reputation of the various soils. Each physical property is then allotted points and the soils studied are rated for physical excellence.

Much work has been done on the formation of crumb structure in surface soils, but little has been done on the fundamental causes of variations in permeability found in subsoils.

The second part of the paper suggests causes of high permeability to water of the subsoils of several Victorian soils, and experiments carried out to test these hypotheses are described.

Soils with a high content of free ferric oxide and Kaolinitic clay minerals are permeable because of pores between stable aggregates formed from the stable koalin and cementing ferric oxide. Some clays with a high proportion of sand are permeable because of pores between the sand grains and clay aggregates among the sand. Some subsoils in Northern Victoria are permeable because of their high salt content keeping the clay flocculated.

Peaty soils appear to be permeable because of the stable porous fabric of the organic material.

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LEGUME BACTERIOLOGY IN THE TROPICS

D. O. NORRIS

Few people are aware that Australia had a legume bacteriologist as long ago as 1899. His name was Greig-Smith, he occupied the position of Macleay Bacteriologist to the Linnean Society for some years, and his first paper on "The nodule organism of the Leguminosae" appeared in Volume 24 of The Proceedings of the Linnean Society. This was at a time when it was by no means settled what was the exact nature of the organism we now call *Rhizobium*. Greig-Smith inclined to think it a yeast, differing in his view from Beijerinck who only 11 years before, in 1888, had first isolated the organism and founded the scientific study of *Rhizobium*.

Following this brief interlude there appears to have been a period of 30 years in Australia when legume bacteriology was officially ignored, until Harold Pittman, then Plant Pathologist to the Department of Agriculture of Western Australia, took it up again. His popular account published in 1935 in the Journal of the Department of Agriculture of W. Australia marked the opening of the modern era in Australian *Rhizobium* study. I would like to pay tribute to his energy and enthusiasm in this field, particularly for his pioneering of the issue of agar cultures of tested strains to Australian farmers. Although it is not marked by a string of scientific papers in the literature his work has undoubtedly been of very great service to Australia.

In the 14 years since World War II there has been a rapid development of interest in this field in Australia. There are now possibly twenty workers devoting themselves mainly to *Rhizobium* at the research level, and as many concerned part time or with the commercial production of cultures. A considerable number of closely associated agrostologists and agronomists are interested in field aspects of the problems of nodulation. The post war period has also witnessed the rise of the commercial peat culture industry and the progressive withdrawal of Departments of Agriculture from the issue of cultures to farmers.

I would like to point out that of the *Rhizobium* research workers in this country, only two are north of the Brisbane Line and have any contact with tropical legumes. This situation in Australia repeats in miniature the development of the world pattern of *Rhizobium* research. Taking Beijerinck's isolation of the organism in Holland in 1888 as a starting point, this research has been essentially a product first of Europe, later of northern America. In the early days research was mainly due to individuals. Subsequently schools arose, two notable examples of which are at Rothamsted and at Madison, Wisc. The scattered papers dealing with legumes in tropical countries that one finds through the literature are very largely due to students who were trained in these centres and subsequently carried on the tradition in their own countries.

It is, therefore, not surprising that the legumes most prominent in the agriculture of north temperate countries have supplied the *Rhizobium* for the bulk of the studies in this field. Of particular importance in this agriculture are the two tribes *Trifolieae* and *Vicieae*

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of *Papilionaceae,* and within the tribe *Trifolieae* the two genera *Trifolium* and *Medicago.* Species within these genera have occupied a high proportion of the research time devoted to *Rhizobium* in the temperate southern half of Australia. When students are taught about *Rhizobium* in Universities it is largely the characteristics and behaviour of clover and medic *Rhizobium* that is being taught. As an instance, the classical picture of nodule initiation resulting from a process of root hair curling, followed by the development of an infection thread invading the hair, is based on studies in *Trifolium* and *Medicago.*

Distribution of Leguminosæ

It is unfortunately true that very few *Rhizobium* workers or associated agronomists have more than a vague idea of the broad botanical relationships and geographical distribution of the Leguminosae. I have met several people who have dismissed tropical legumes quite lightly as of little consequence because there are not many of them, or because they do not nodulate, or because if they do nodulate they fix very little N. What these people are really doing is admitting to a grevious state of ignorance. This situation is brought about, to a considerable extent, because there is no publication to which one can turn to gain a comprehensive picture of the Leguminosae. An outline of the relationships of the legumes has now been provided by Professor Tutin of the University of Leicester to fill the needs of the Fifth Easter School at the University of Nottingham (Tutin 1958), but it is probably still safe to say that there is today no single man who can give an authoritative statement on the number of valid species, or even genera in Leguminosae. There has been no comprehensive revision of the Order since Taubert's monograph in 1894. This is one of the greatest deficiencies in the equipment of the modern agriculturist struggling to raise world food production, and one on which I think action should be taken at the international level.

However if we make use of what we have and study Taubert to get an approximate picture of the distribution of present-day Leguminosae, it is soon evident that the tropics are the real home of the legumes. Of the three great sub-divisions, two, *Caesalpiniaceae* and *Mimosaceae,* are almost entirely confined to the warmer regions of the earth with the notable exceptions of *Cercis, Gleditschia* and *Ceratonia* in the former, and *Acacia* in the latter. The third, *Papilionaceae,* provides the bulk of temperate species.

The reasons for this distribution are made clear in a paper by E. C. Andrews presented first to the British Association for the Advancement of Science, and subsequently published in the Journal of the Royal Society of N.S.W. (Andrews 1914). Andrews was geologist to the Mines Department of New South Wales, but he combined botany with geology to good advantage in this analysis of the origins of the legumes. To put the story in brief outline the Leguminosae are of fairly ancient lineage, having arisen first in Upper Cretaceous times. At that time, and for a considerable subsequent period, a large proportion of the earth's surface enjoyed a moist,

TABLE 1

Distribution between Tropical and Temperate zones of genera and species of Leguminosae.

Family	Genera and species in tropics and sub-tropics	Genera and species in temperate and cool temperate zones
Caesalpiniaceae	89 - 988	7 - 44
Mimosaceae	31 - 1200	1 - 141
Papilionaceae	176 - 2430	141 - 3084

mild climate, somewhat similar to that of the humid tropics of to-day. As the ages have gone by the legumes have continued to flourish in the humid tropics, but this climatic zone has in the long run contracted to its present restricted limits. Two of the great sub-divisions, *Mimosaceae* and *Caesalpiniaceae,* have not moved with the times but have remained restricted to the warm zones. The third subdivision, *Papilionaceae,* has shown great plasticity, and has adapted with great vitality to temperate and cold temperate regions. Most of its tribes show this adaptation by possessing generalized tropical genera and specialized temperate genera. For instance, in *Genisteae* the generalized tropical type is found in the genus *Crotalaria* and the specialized, usually polyploid, temperate types in such genera as *Lupinus* and *Genista.* But in addition, whole new tribes have arisen completely within the temperate regions. Two of these tribes are the *Trifolieae* and the *Vicieae.* It is my hypothesis that the *Vicieae* may even have arisen from the *Trifolieae* (Norris 1959). This then is the important point we must grasp; that the classical picture of the *Rhizobium* symbiosis is based largely on studies of the type of bacterium associated with the most recent and highly adapted types of the host.

If we examine the type of bacterium that is associated with a very wide cross-section of the generalized tropical legumes we find that it is in general a culturally slow-growing type, producing little gum, in contrast to the clover type which is fast-growing and gummy. It has a strong tendency to produce an alkaline reaction in culture media in contrast to the clover type that produces acid. When associated with the host it shows a strong tendency to be symbiotically promiscuous, whereas the clover type is highly strain specific. In various other ways it adds up to the fact that the tropical type, the "cowpea type," is different from that associated with clovers. In view of the evolutionary history of the legumes just outlined it takes small powers of deduction to conclude that the "cowpea type" represents the ancestral and typical condition of *Rhizobium,* and the fast-growing clover type is a specialized condition. The dangers of basing our classical beliefs about *Rhizobium* on studies done with the clover type should be evident.

What is the impact of all this on the legume bacteriologist in the tropics? In general it means that he must be wary of what he has learned as a student and should adopt at all times a healthy scepticism. I would like to point out just a few of the places at which an open mind may prove an advantage.

The question of root hair infection.—Is it not possible that this traditional picture of nodule initiation may be true of only a minority of legumes? It has already been shown that in some legumes, e.g., peanut (Allen and Allen 1940) root hairs are few. They consist of short outgrowths from cells and play no part in infection. Nodules are initiated by wound infection at the point of emergence of a lateral root. Such a wound invasion seems to me far more likely to represent the primitive type of infection by a symbiont. How many tropical legumes have root hairs comparable with those of clover?

The form and appearance of bacteria in culture.—Although the classical *Rhizobium* is white, cream or translucent, two perfectly normal red strains have been isolated in my laboratory, one from *Lotononis bainesii* (Norris 1958*a*), and one from *Listia heterophylla.* A rusty brown culture has been obtained from *Mimosa pudica.* What further variability may be encountered as tropical legumes are explored? The hypothesis of Bisset (Bisset and Hale 1951; Bisset 1952, 1958) that *Rhizobium* is, in fact, a spore-forming member of the *Bacillaceae,* and that the classical opinion to the contrary is based on the study of atypical forms that are "suggestive of the degeneracy often associated with parasitism" will, I feel sure, be substantiated once an examination is made of a range of strains from the more primitive tropical legumes.

The concept of Cross-Inoculation Groups.—This is a firmly entrenched traditional teaching that needs to be treated with caution. A closely strain-specific group like the clovers represents a condition of degenerate specialization. The freely cross-inoculating species like the

cowpea is the primitive condition. In studying tropical legumes, species possessing the ability to cross-inoculate with cowpea will be continually encountered in all tribes and in each of the Families of Leguminosae. They cannot by any means be made to constitute a group. To talk of a species belonging to "The Cowpea Cross-Inoculation Group" is to talk scientific nonsense. No reputable tropical legume bacteriologist should commit this error, but should rather speak rationally of a species as possessing cowpea-type *Rhizobium* and being either strain specific or promiscuous, or some degree in between.

Claims that tropical legumes fail to nodulate.—This is a situation that should be treated with reserve until much more information is available. Bowen (1956) reported no lack of nodules on many tropical legumes in Queensland, but observations such as those of Masefield (1957) in Malaya, or Bonnier (1957) in the Belgian Congo, indicate that under some circumstances it is difficult to find nodules on many tropical species. The question is does this relate to the nature of the legume, or is it due to the environmental circumstances of the moment? My own reaction to a tropical legume that had been found upon excavation to bear few or no nodules would be to look at it from the point of view of its vegetative vigour. If it were obviously green and vigorous my conclusion would be that it stood in no need of nodules in this particular time and place, but I would be fully prepared to find it nodulated well at some other time and place. There are two factors to keep in mind here. One is that there may well be a cycle of nodulation, particularly in areas with a distinct wet and dry season. Just as one observes flushes of growth in the tops, there may be flushes of nodulation followed by periods of nodule decay. This pattern has, in fact, been shown by Hannon (1949) in certain Australian species. The second factor which has not been invoked in this matter, but which may be of profound importance, is soil nitrate. It is now well established that soil nitrate may often achieve high levels in tropical soils, even in quite poor soils. There is characteristically a great surge of nitrification following the onset of the wet season in monsoonal areas resulting in a high peak of soil nitrate that tails away as the season progresses (Hagenzieker 1957; Greenland 1958). It is well known that soil nitrate can have a strong inhibitory effect on nodulation (e.g. Giöbel 1926; Thornton and Nicol 1936).

In the Cunningham Laboratory, Brisbane, we recently had an instance of a krasnozem soil collected from virgin rain forest at Beechmont, Queensland, on which nodulation of *Phaseolus lathyroides* by a known effective strain was either entirely suppressed or reduced to a few tiny ineffective nodules. The soil on incubation for 30 days produced the astonishing level of 230 p.p.m. of nitrate-N (Fergus, unpublished data). From the converse point of view, in my own strain testing work I have not as yet encountered a tropical legume that has failed to develop good nodultion under the nitrogen-deficient conditions supplied in greenhouse tests.

Claims that tropical legumes fail to fix nitrogen.—This, of course, is closely involved with the foregoing discussion. Simultaneously with the actual inhibition of nodule formation by nitrate there is interference with the efficiency of those nodules that do develop. They remain small and ineffective and may give a false impression of an ineffective symbiosis. This situation is very likely to occur under an old stand where soil nitrogen level will have been built up by the activities of the legume itself. However it is quite evident from pot culture studies under low nitrogen conditions that where there is no nitrate inhibition the symbiosis proceeds just as well in tropical as in temperate legumes. Some careful experimental evidence is available from pot experiments with *Centrosema pubescens* (Watson 1957) and field experiments with *Glycine javanica* (Jones 1942) and *Acacia mollissima* (Orchard and Darby 1956) that shows these species to be nitrogen fixers of an efficiency quite comparable with clovers.

The practice of inoculation in tropical legumes.—There is just as great a need in the tropics as elsewhere for careful bacterial strain

testing and selection of highly effective types. As a broad general rule it may be said that legumes with cowpea-type *Rhizobium* are more promiscuous and therefore likely to pick up an effective bacterial strain naturally, but there are, undoubtedly, all degrees of symbiotic specialization amongst them. An extreme instance is *Lotononis bainesii,* a South African legume which so far has reacted effectively with only one strain of *Rhizobium,* which is itself highly specialized, being red in colour. With *Stylosanthes* species I have encountered the situation that while many strains may nodulate, only a few are really effective. Furthermore, a strain that is fully effective on one *Stylosanthes* species may quite refuse to nodulate another *Stylosanthes* species. The wait-and-see attitude that has been adopted by the Queensland Department of Agriculture and Stock to the whole question of handing over the *Rhizobium* service field to commercial interests is amply justified. We have a long way to go before this may be safely done.

The calcium nutrition of Rhizobium.—The belief that *Rhizobium* is a calcium sensitive organism seems to represent a transposition of ideas. Its origin appears to be that Foote, Peterson and Fred (1929) in Wisconsin found that certain cultures grew better and survived longer when $CaCO_3$ was added to the culture medium. The strains they used produced acid which was neutralized by the $CaCO_3$. The custom of adding $CaCO_3$ became general, but sometimes $CaC1_2$ was substituted for the $CaCO_3$. Unfortunately for this custom when we take the trouble to examine a cross-section of *Rhizobium* strains we find that acid production in culture is characteristic of a minority only, notably of strains from *Medicago* and *Trifolium.* Most cowpea-type strains actually produce an alkaline reaction. The addition of $CaCO_3$ to the growth medium is pointless for these strains. More unfortunately still for this custom incontrovertible evidence has just been obtained (Norris 1958*b*) that if *Rhizobium* does indeed need Ca it must be in the most minute traces only. This evidence was obtained by using 48 strains representing a good cross-section of Leguminosae and growing them for many generations in a chemically defined medium in which Ca was reduced by special purification of ingredients to < 0.1 p.p.m. Further experiment proved that the element to which *Rhizobium* is really sensitive and which it must have is magnesium. If it does indeed possess a Ca need this must be quite capable of being satisfied from the impurities normally present in culture media.

The necessity for lime in acid soils.—It is quite well known that in growing clovers and medics a lower limit of about pH 4.5 for clover and 5.0 for medics is set below which we must lime to get nodulation. This is partly due to sensitivity of the *Rhizobium* to acidity, but mainly due to the insufficiency of Ca for the Ca-sensitive process of nodulation to go on successfully (Loneragan and Dowling 1958; Loneragan 1959). These observations, true enough for clovers and medics, have frequently been taken as basic facts that apply to all legumes, and lime has been applied to tropical legumes on tropical soils simply because the pH was at a certain arbitrary level. An example of this is to be found in the literature from Puerto Rico (e.g. Loustalot and Telford 1948; Landrau, Samuels and Rodriguez 1953) where the growth of tropical kudzu, *Pueraria phaseoloides,* was being undertaken on acid soils. It was assumed that because it was a legume it needed lime and large dressings were applied. Examination of the data shows that the legume was quite satisfactorily modulated even at pH 4.0; the assumption that lime was needed being quite unfounded.

We now have evidence in the C.S.I.R.O. Cunningham Laboratory, Brisbane (Norris 1958*c*) that the tropical legume as a class is a very efficient extractor of Ca from soils of low Ca content, and can, therefore, get its needs from soils in which clovers and medics are unable to grow, let alone nodulate.

The whole question of lime and nodulation must, therefore, be viewed with circumspection when dealing with tropical species. Each species should be treated on its merits. The assumption that because the soil is acid it should be limed to get good legume growth can waste much valuable time and money. It

may even have seriously harmful effects on a soil of very low exchange capacity.

The tropical legume bacteriologist has a fascinating field of research at his feet. It is in his field that the norm of the symbiosis is to be found, and it is his responsibility to begin the studies that will reveal the norm and correct our present impressions of *Rhizobium* that are based on specialized types. However in the first place these studies need to be essentially of a broad scale, reconnaissance type, not an examination of minutiae such as those made on the genes resulting in ineffectiveness in one variety of one species of clover. The taxonomic position of the host plant within Leguminosae should be a prime consideration in all such studies.

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Technical Notes

Lateral Movement of Fertilizer Sulphur

For maximum economy and uniformity of the experimental area, it is desirable in field experiments with plant nutrients that the size of the individual plots should be fairly small. One of the important restrictions in reducing plot size is the extent to which lateral movement of nutrients can occur. Bentley, Hoff, and Scott (1955) have reported that plants as far as two feet from fertilized areas may take up fertilizer sulphur, but it was not clear whether this was due to movement of sulphur or to root extension. Apart from this report there does not seem to be any information on the extent of lateral movement of sulphur.

In a large series of plant nutrition experiments on the Northern Tablelands of New South Wales lateral movement of sulphur usually did not seem to be very great and borders of plots were usually quite sharply defined. There were however two exceptions. In both cases the experimental area was situated on a moderate slope and on a soil type that was characterized by a fairly permeable top-soil with a less permeable sub-soil. Details of one of these sites are given here.

This site was on the lower slopes of a hill (3°) about 15 miles north-west of Guyra on a soil derived from porphyry. The A_1 horizon is a dark grey fine sandy loam which overlies a pale grey loamy sand (A_2) becoming gravelly with depth due to an increasing proportion of ironstone concretions. At about 16 inches there is a sharp transition to the B horizon, a yellow and brown mottled sandy clay. The pH of all horizons is approximately 6.2.

Two experiments were sown to phalaris (*Phalaris tuberosa* L.) and subterranean clover

Figure 1.—Gradient in growth of pasture with increasing distance from top edge of plot in November, 1956 (Exp. B). The measuring stick is 18 inches tall. A at top of plot; B 12 feet from the top; C 25 feet from the top.

(*Trifolium subterranean* L.) in March, 1955. Experiment A was designed to test responses to sulphur, and therefore certain of the individual plots received sulphur as two cwt per acre of gypsum in March, 1955, and again in February, 1956.

Experiment B was designed to test responses to other nutrients and received overall dressings of four cwt per acre of superphosphate in March, 1955, two cwt per acre of sulphate of ammonia in September, 1955, and two cwt per acre of superphosphate in February, 1956.

During the winters of both 1955 and 1956 the soil was saturated with water. In 1955 the pattern of spring growth on experiment A suggested that slight downhill movement of sulphur had taken place. When sulphur deficiency had become well-marked in the spring of 1956, it was clear that appreciable movement of sulphur* had occurred. Not only had sulphur been washed downhill from the fertilized plots into the unfertilized ones but the uphill side of the fertilized plots had become sulphur-deficient. There was thus a tendency for the area responding to sulphur to be displaced several feet down the slope.

The movement of sulphur from the uphill part of the fertilized areas was well illustrated by experiment B. Although this area had received about 115 pounds of sulphur during the preceding 21 months the uphill part was very sulphur deficient. Symptoms of sulphur deficiency were well-marked and production was much reduced. The uppermost row of plots, extending 12½ feet from the edge of the area produced 25.7 cwt per acre of pasture on an oven dry basis (Fig. 1a). The next row extending from 12½ feet to 25 feet from the edge, produced 49.7 cwt (Fig. 1b and 1c), the third row 52.4 cwt, and the fourth 57.6 cwt. There was little change in the production from subsequent rows.

It is tempting to suggest that this movement of sulphur was a consequence of lateral movement of water in the permeable horizons though surface movement of water is not precluded. Lateral movement of sulphur on a scale such as this may invalidate an experiment and small plot work under similar conditions to those described may be impossible.

* The identity of the element concerned was confirmed by responses to added sulphur in 1957.

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The Loss of Applied Phosphorus and Sulphur from Soils under Pasture in W.A.

Three soil types under virgin conditions and under established pasture have been examined at Coolup on the Swan Coastal Plain.

A significant loss of the phosphorus applied in the superphosphate has been revealed for two of the soils while a considerable loss of sulphur was noted for all three soils. These results contrast with those reported for a podzolic soil at Crookwell, N.S.W., by Donald and Williams (1954) and Williams and Donald (1957).

A build up of organic matter was found in all three soils, but although this was similar

TABLE 1.

Change in balance of carbon, nitrogen, sulphur and phosphorus and build-up of organic matter in soils under pasture at Coolup, Western Australia

Soil Type	Land Use	C/N/S/P	Increase in Organic Matter Tons/acre	Superphosphate cwt/acre applied	Increase of P, N, and S per cwt of superphosphate * applied.		
					lb P.	lb S.	lb N.
Coolup sand	Virgin	238/10/2.1/0.85	13.7	55	3	4	31
	Pasture	131/10/1.5/0.85					
Boyanup sandy loam	Virgin	169/10/1.6/0.65	7.4	19	2	12	56
	Pasture	140/10/1.8/0.55					
Blythewood sand	Virgin	232/10/1.6/0.68	0.4	6.4	10	6	44
	Pasture	210/10/1.6/0.97					
Podzolic soil Crookwell, N.S.W. (Donald and Williams *loc. cit.*)	Virgin	161/10/1.5/0.73	13	13	10	13	85
	Pasture	153/10/1.4/0.66					

* Superphosphate containing 10 lb P and 13 lb S per hundredweight.

in nature to that obtained at Crookwell the increase per hundredweight of superphosphate applied was smaller, probably due to the lower retention of phosphorus and sulphur by these soils.

The three soils studied, Coolup sand, Boyanup sandy loam and Blythewood sand are representative of soil types occupying the most extensive areas of the agricultural district of the Swan Coastal Plain. Their distribution and properties are discussed in detail by McArthur, Bettenay and Hingston (in press). The essential features of the soils studied are as follows:—

Coolup sand: Twelve to eighteen inches of grey sand—having 3 per cent. clay, 0.02 per cent. free iron oxides and a pH of 6.1 in the surface 6 inches—overlying a grey and brownish yellow mottled sandy clay.

Boyanup sandy loam: One to two inches of greyish brown sandy loam over yellow-brown clay—having 43 per cent. clay, 3 per cent. free iron oxide and a pH value of 5.8 in the surface 6 inches—and becoming grey and brown mottled and finer textured with depth. Boyanup sandy loam has a micro-relief associated with gilgai development. However at the spot sampled, few depressions were evident and these were avoided in sampling.

Blythewood sand: Brown fine sand—having 9 per cent. clay, 1 per cent. free iron oxides and a pH value of 6.5 in the surface 6 inches, with red fine sandy clay at 12 inches.

The average annual rainfall for the district is 38 inches with a marked winter incidence and a long summer drought.

Each soil type was sampled from both a virgin area and from an adjacent paddock of known history. A grid of ten sites one chain apart was selected in each area and each site was sampled from a further grid of ten auger holes six inches deep and one yard apart. The auger samples were thoroughly mixed to form a composite sample for each site.

Results

A summary of the C:N:S:P: ratios, total increase in organic matter, and increases in phosphorus, sulphur and nitrogen per hundredweight of superphosphate applied is given in Table I. Included in the table for comparison are the results for the podzolic soil examined by Donald and Williams. This table shows a lowering of C/N ratio and considerable build-up of organic matter, total phosphorus, sulphur and nitrogen under pasture development. However, large amounts of applied phosphorus have been lost from the surface of Coolup sand and Boyanup sandy loam and sufficient samples were analysed for statistical treatment (Table 2) to indicate that this loss is highly significant. The results for sulphur were obtained on bulked samples so that statistical tests could not be applied but a loss of applied sulphur is indicated for the two strongly leached soils Coolup sand and Blythewood sand.

In the case of Coolup sand it has been shown in the laboratory that superphosphate applied at the rate of one hundredweight per acre to the surface of a six inch column of soil is readily removed with the equivalent of thirty inches of leaching water applied over a period of 21 days. This is probably due to the relative absence of clay and iron oxides which are known to absorb phosphorus. Waterlogging the soil for 2 days in the column before leaching commenced increased the phosphorus removed in the first fractions of leachate by approximately 20 per cent. Coolup sand is waterlogged in winter due to the slow escape of drainage water and the loss of phosphorus from the surface of this soil through leaching would be very great.

In similar experiments with Boyanup sandy loam and Blythewood sand no phosphorus could be detected in the leachate. Sesquioxides and clay in these soils probably absorb the applied phosphorus. When these soils were kept in a waterlogged condition they still retained all the phosphorus applied. In view of this it is surprising that there is a loss of phosphorus from Boyanup sandy loam in the field. However, it is suggested that in Boyanup sandy loam applied phosphorus would be immediately absorbed in a thin veneer of surface soil which is susceptible to dispersion and removal in runoff. An examination of the clay material that had collected in a natural trap in a gilgai depression showed

TABLE 2.

The loss of applied phosphorus and sulphur from soils under pasture at Coolup in Western Australia

	Coolup sand Under pasture for 27 yrs.		Boyanup sandy loam Under pasture for 20 yrs.		Blythewood sand Under pasture for 3 yrs.	
	Phosphorus lb/acre	Sulphur 6 ins.	Phosphorus lb/acre	Sulphur 6 ins.	Phosphorus lb/acre	Sulphur 6 ins.
Pasture sites	186	340	170	580	179	300
Virgin sites	31	100	133	340	109	260
Increase under pasture*	155	240	37	240	70	40
Removal in beef, milk and calves	25	—	19	—	1	—
Total accounted for	180	—	56	—	71	—
Total applied in superphosphate	620	800	216	280	72	93
Loss from the surface 6 ins.	440	560	160	40	1	53
* Statistical Data† (1) S.E. of difference between means of determined phosphorus on 18 d.f. i.e., S.E. of increase under pasture	12.5	—	14.7	—	13.4	—
(2) 95% fiducial limits‡ for (1)	±26		±31		±28	

† Analysed by C. A. P. Boundy, C.S.I.R.O. Division of Mathematical Statistics, Perth, W.A.
‡ No error can be calculated for phosphorus removed in farm products and applied in superphosphate. However, even if this error was as high as 20% the loss is still significant in the Coolup sand and Boyanup sandy loam.

NOTE: 1 acre 6 ins. of soil has been taken as 2,000,000 lbs.

a phosphorus content of 425 p.p.m. and the loss of phosphorus could thus be explained by removal of only 0.05 inches of clay annually. Since sulphate is not absorbed in the same way as phosphate it may be leached beyond the surface veneer, but because leaching is slow in this soil the sulphate is not moved beyond the six inches sampled.

It has been found that for some soils accumulation from a total of 15-20 hundredweight of superphosphate per acre is sufficient to raise the phosphorus content to adequate

levels (Woodroffe and Williams 1953; Cariss and Dunne 1953; Sims 1953; Spencer 1958). However, this investigation indicates that for these soils accumulation may not be sufficient to overcome the initial extreme deficiency. The retention of phosphorus equivalent to only 14 of the 55 hundredweight per acre applied to Coolup sand and 3 of the 19 hundredweights applied to Boyanup sandy loam increases the total phosphorus in the surface six inches to only 93 and 85 p.p.m. respectively.

In view of the importance of phosphorus in the development of low fertility soils through pasture establishment, further work is in progress to test the mechanisms of loss and define more clearly the build up of plant nutrients.

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Some Nematodes as Factors in Yield Reduction and Spawn Degeneration in the Cultivated Mushroom *Agaricus hortensis* (Cke.) Imai

In recent years there have been reports of serious yield losses in outdoor mushroom ridge beds in the Sydney Metropolitan area. During the 1958 season, many surveys were made of commercial mushroom growing projects, mostly outdoor ridge beds, to determine the extent of nematode infestation of the beds and the association of this infestation with yield reduction. In a number of beds examined during the period March to October, it was found either that the mycelium had made little growth after spawning and had eventually disappeared from the bed or that establishment of spawn was normal and the expected yield as indicated by the first flush was promising but, subsequently, degeneration of the spawn occurred and the following flushes were reduced or absent.

Samples of compost were taken from beds with different levels of production. The nematode population in each sample was extracted by a modification of the Baermann funnel technique (Anderson and Yanagihara 1955) and an estimate made of the total number of nematodes present in each sample.

A high nematode population (greater than 5,000 nemas per 100 g moist compost) appeared to be associated with a low yield (less

than 1 lb mushrooms per square foot) and conversely a low count (less than 500 nemas) was associated with a high yield (greater than 1½ lb), and with the presence of abundant mycelium in the beds.

Nematode Fauna Present

The nematodes extracted represented many genera, some of which are inadequately described. A species of *Ditylenchus* was frequently encountered characterised by six lateral fields and the following measurements:

	Female	Male
l	0.890	0.708
a	30.0	33.5
β	7.3	5.7
γ	14.7	12.4
V	82.7%	T. 57.5%

This nematode conforms to *Ditylenchus myceliophagus* J. B. Goodey (1958). (Figure 1). Other genera identified were *Rhabditis* spp., which occurred most commonly, *Aphelenchoides* sp., *Diplogaster* sp. and *Rhabditella* sp. The *Rhabditis* species most frequently recovered conformed to the published description of *R. terricola* Dujardin (T. Goodey 1951) (Figure 2).

Effect of Nematodes on Spawn Growth in Grain Cultures

To assess the ability of the *Rhabditis* spp., and *D. myceliophagus* to destroy mushroom mycelium, populations extracted from three failing beds were introduced, each at three concentrations, into established rye grain mushroom cultures. The inoculated cultures were incubated for up to 18 days at 25°C. At the end of the experimental period the nematodes present in each culture were extracted and the population estimated (Table 1).

In this experiment, marked degeneration of the mycelium of *A. hortensis* was observed, but the form of the degeneration varied with the nematode inoculum used. In the case of *D. myceliophagus* the spawn, although degenerate, was relatively free of bacterial contamination and the culture had a dry texture and browinsh appearance. On the other hand, in cultures inoculated with *Rhabditis* sp. there was a marked development of bacteria. A viscous matrix bound the degenerating mycelium into wefts along and between which nematodes move freely. (Figure 3). Van Haut (1956) noted bacterial activity in association with *Rhabditis* spp. and suggested that the nematodes produced a metabolite which enhanced the bacterial flora. He showed that bacteria alone were unable to cause a reduction in the growth of the mycelium which occurred only when the nematode was also present also that with an inadequate supply of bacteria, the rate of multiplication of *Rhabditis* spp. decreased and the larvae failed to mature.

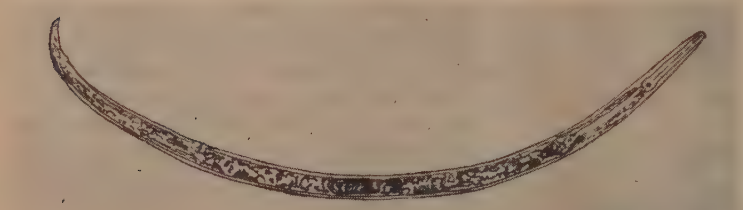

Figure 1—Ditylenchus myceliophagus (J. B. Goodey).

Figure 2—Rhabditis sp.

The results presented in Table 1 show that an increase of up to 180 fold occurred in the *Rhabditis* population but the *D. myceliophagus* population remained relatively static. The vigorous *Rhabditis* population possibly adversely affects spawn growth by direct competition for available nutrients, or the nematode metabolites excreted may inhibit growth directly or indirectly by stimulating an active bacterial flora. In the case of *D. myceliophagus,* however, a much smaller number of nematodes feeding directly on the spawn is apparently able to destroy it. Cairns and Thomas (1950) observed cytoplasm escaping from tiny punctures in the hyphae made by this nematode.

Source of Nematode Infestation and Control

An attempt was made to trace the principal source of nematode contamination of mushroom beds in local culture. Three possible sources were considered: (1) The manure component of the compost heap, (2) The fresh cereal straw used to cover beds or incorporated with manures during composting, and (3) the soil used to case beds or upon which the compost heap or bed is built.

Fresh cow and poultry manures and fresh manure-straw mixtures from horse stables, almost invariably were rich in saprophytic species of nematodes. On the other hand, baled straw and the heavy textured soils used to case ridge beds, or upon which they were located, did not appear to be significant sources of inoculum. Samples from fully composted heaps, collected prior to the compost being formed into beds, showed that, regardless of the source of the animal manure used, heaps contained a vigorous population of nematodes.

In a fermenting compost heap there is an uneven distribution of temperature (Kligman 1950) and it could be expected that nematodes would survive in the cooler periphery and the centre of the heap. Foci of nematodes persisting in these relatively cool areas in compost heaps constitute perhaps the most significant source of contamination under local conditions, and it is suggested that field control

TABLE 1

Growth of nematode population following introduction to mushroom cultures on rye grain media

Inoculum	Initial Nematode Population Introduced	Estimated* Nematode Population Recovered
Complex of	75	1,800 after 18 days
Rhabditis spp.	150	6,200 „ „ „
(ex *Maraylya,* N.S.W.)	300	56,300 „ „ „
Complex of	840	5,300 after 11 days
Rhabditis spp.	1,680	3,300 „ „ „
(ex *Granville,* N.S.W.)	8,400	276,300 „ „ „
Ditylenchus	40	56 after 13 days
myceliophagus	80	200 „ „ „
(ex *George's Hall* N.S.W.)	550	170 „ „ „

* Mean of six replications

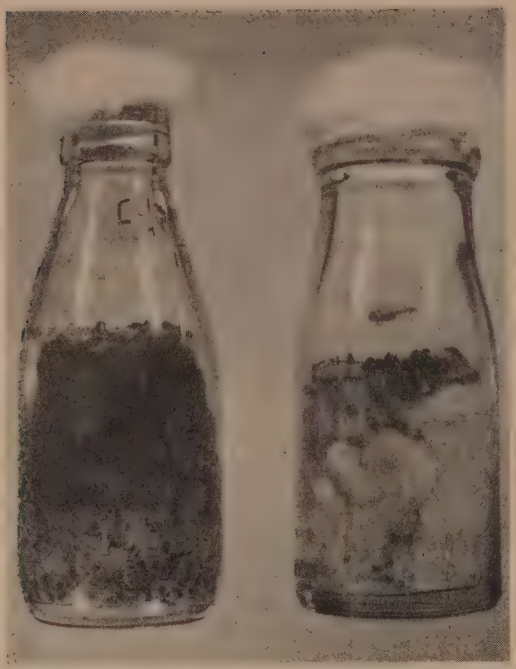

Figure 3—Left: Grain culture inoculated with Rhabditis spp., showing destruction of mushroom spawn. Right: Uninoculated control.

of this problem should be directed towards eliminating this inoculum. It is possible that by meticulous turning of the heap during composting all the material would reach a temperature lethal to all nematodes present. In actual fact such care is not practicable and the use of composting machinery further precludes such thoroughness. Overseas, where nematodes have been recognised for some time as factors in reducing the yield from mushroom beds, the inadequacy of the heat generated during composting is realised. Van Haut (1956) showed that *Rhabditis* nematodes survived the short composting process and then multiplied rapidly. All compost during its preparation is submitted to a "peak heating" of 130-140·F for 24 hours, but such treatment is not given in local culture. The most convenient method in the absence of "peak heating" facilities appears to be fumigation of heaps with methyl bromide (1 lb per 100 cubic feet of compost) immediately prior to the compost being formed into ridge beds.

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Cool Storage to Reduce Herbage Dry Matter Losses After Harvest

Herbage samples from experiments must often be kept for some weeks after cutting before they can be analysed. Delays of over three days between cutting and drying of "shrinkage" samples (for dry matter determination) are also common, especially where plots are away from the home base.

These delays may cause substantial losses in dry matter and should be reduced as far as possible in detailed projects.

Raymond and Harris (1954) measured up to 12 per cent. of dry matter lost from herbage dried at room temperature, and McRostie and Hamilton (1927) warned of the "significant but variable loss of dry matter due to air-drying previous to oven-drying." Both of these

writers also stress the speed of the drying process as important, and Davies *et al.* (1948) developed a process of freeze drying so that respiration is stopped within seconds of the herbage being cut and weighed. For the same reason Raymond and Harris developed a radio-frequency drier and propounded that a fast moisture removal rate is more important than high temperatures (shown by both of these and other writers to alter substantially the amounts of heat labile chemicals in the herbage—Bathurst and Allison 1949) and they advised very loose packing of herbage in the dehydrator.

Experimental

At New England Experiment Farm, Glen Innes, a test was conducted in 1955 to assess the merits of a cool-room (40°F) and deep freeze (0°F) for storage of herbage samples. The loss of dry matter from identical samples hung in calico bags on a verandah was also determined at intervals during the first week, from October 9, 1955. For these 1, 2, 5 and 9 day periods (Table 1) the temperatures averaged 60, 61.5, 63.8, and 61.2°F respectively and the weather was humid and overcast throughout with rain falling each day to total 313 points. An indication of treatment effects under one of the most extreme sets of conditions likely at Glen Innes—except for the moderate temperatures—was expected from the test. The species was red clover and it was cut while vigorously growing and succulent, about one foot tall and wet with mist.

TABLE 1.

Loss in dry matter during air-storage of red clover (samples of 1000 grams) before dehydration at 221°F for 15 hours (to constant weight)

Days after Cutting	Dry Matter as % of Green Weight		
	Range	Av. 4 reps.	% of D.M. lost
0	15.8—16.4	16.10	0
1	15.4—15.8	15.55	3.4
2	14.6—15.1	14.73	8.5
5	13.9—14.8	14.25	11.5
9	13.7—14.3	14.10	12.4

After the red clover was cut it was thoroughly but gently mixed by hand, subsampled and allotted at random for treatment.

In the cool storage test, samples both loosely and tightly packed in their bags were compared.

Because samples were handled as little as possible after cutting, "loosely packed" implied a minimum of bruising of the plant tissues, the calico bags 30in. x 18in. providing ample storage space.

"Tightly packed" samples represented the situation which could be met under field conditions when bags would only just contain the material from high-yielding plots, and then only if it were crammed and pressed into them. Some breakage and bruising of tissues was involved.

Results

The results as summarised in Table 1 show that very high percentage losses of herbage dry matter can occur within two days of cutting.

Table 2 emphasises that care in handling the herbage samples has a strong effect in reducing the losses of dry matter during cool storage, although 9.3 per cent. of D.M. was lost in 40 days at 40°F even when the samples were handled gently—compared with over 17 per cent. loss from rough treatment.

At the deep-freeze temperature of storage, 0°F, only 2.6 per cent. D.M. was lost by the most severely treated samples, while those carefully handled averaged a slight gain of D.M. (1.6 per cent.), unexplained except as experimental error. The slight variations between replicates in all other cases allow confidence in the data for the practical conclusions drawn.

Conclusions

The extra losses recorded at Glen Innes from tightly packed samples suggest that tissue bruising is a factor generally associated with dry matter losses. By handling herbage carefully after harvest, these losses will be minimised.

A cool-room at a temperature of 40°F can reduce losses when samples are stored for short periods and should be preferred to leaving them in the open-air. However, this is not a sufficiently cold temperature for retention of

TABLE 2

Loss of dry matter during cool storage of red clover (samples of 1000 grams) before dehydration at 221°F for 15 hours (to constant weight)

Packing	Temperature for 40 days	Dry Matter as % of Green Weight			% of Dry Matter lost.*
		Range		Av. 3 reps.	
Loose	0°F	15.1	16.1	15.6	−1.6
Tight	0°F	14.8	15.0	14.9	2.6
Loose	40°F	13.8	14.0	13.9	9.3
Tight	40°F	12.6	13.1	12.8	17.0

*i.e. D.M. weight of samples dried immediately upon cutting, minus D.M. weight after 40 days of storage, expressed as a percentage of the former.

samples over long periods. A deep-freeze unit at 0°F, is better, and allows numerous samples, such as those for botanical separation, to be kept until time allows them to be handled. This procedure is similar to the proposals of the Joint Committee of four American Societies (1952).

Acknowledgements

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Effects of a Chemical Desiccant on the Speed of Curing of Hay

Much of the loss of nutrients during field curing of hay results from the lengthy exposures and extra mechanical operations necessary when mild or wet weather is encountered after mowing. Crushing of newly mown material between steel rollers to promote more rapid curing is a development of

recent years. Application of chemical desiccants before, during or after mowing might also be expected to speed curing.

Chemical desiccation of potato haulms, of legumes and cereals before harvesting for seed or grain, and of cotton plants, to remove leaves, have been used on a commercial scale, but similar attempts to accelerate curing of hay have not been promising (Kennedy, Hesse and Johnson 1954; Shaw and Ahlgren 1955).

The more important requirements for desiccants to accelerate the curing of hay are:

1. The desiccant should be cheap and its mode of action should preferably permit spraying while mowing to avoid the extra expense and crop damage involved in a separate operation.

2. It should not affect the nutritional value of the cured hay, should leave no residues harmful or unpalatable to stock and should not harm the parent plants, particularly perennials.

3. The rate of drying of leaves should not be increased relative to that of stems since this would increase susceptibility to shatter loss during curing.

A desiccating, selective herbicide, ethylene dipyridilium dibromide, was recently developed by Imperial Chemical Industries (Brian *et al.* 1958). A sample of the crystalline material was provided by Mr. B. D. Robinson, I.C.I. Merrindale Research Station, Croydon, Victoria, for testing for suitability as a hay desiccant. It was described as having high toxicity compared with most current hormone-type herbicides (oral MLD50 in rats of about 440 mg/kg) but was reported to decompose to a non-toxic form after short field exposure. Its use as a weedicide involves application at 1-4 lb per acre. Lower rates seemed appropriate for use as a hay desiccant.

Exploratory tests showed promise of the requirements listed above being met by this desiccant and these and more extensive tests are reported here.

Experimental

Three series of tests were carried out.

"Agral LN" wetting agent was used in all spray solutions at 0.3 per cent. concentration and the spray was applied to standing pastures. With each series, triplicate test plots were cut immediately after spraying and field cured on the stubble on trays consisting of strings spaced at 3 in. intervals across light wooden frames. Rates of drying were observed by both periodical weighing (2 hr intervals during the day) and by daily or twice daily moisture content determinations on representative samples (oven drying at 103°C for 16 hr).

Details of the three series of tests are as follows:—

1. Spraying of 1 sq. ft. plots of lucerne, white clover and H1 (short rotation) ryegrass at rates of 2, 4, 6 and 8 oz per 40 gal water per acre. A 1 pint pressure atomiser was used.

2. Applications of 6 and 8 oz per acre on 6 ft. x 8 ft. plots employing a knapsack spray which applied the solutions in a manner generally similar to that of conventional low volume boom sprays.

3. Applications of 8 oz per acre on 6 ft. x 8ft. plots. The spray nozzle was allowed to brush over and disturb the tops of the crops, after the manner of a low set boom spray, to promote more efficient wetting of the stems and lower levels of the standing crops. In this series, some of the newly mown material was subjected to crushing with a hand operated clothes wringer at pressures similar to those employed in commercial hay crushers. Further plots were sprayed and left standing for two days before harvesting.

Results and Discussion

In the first tests, 2 and 4 oz applications had little effect on drying rates and 6 oz showed less promise of useful desiccation than 8 oz applications. In the second series, desiccation effects were slight and this was attributed to failure of the spray to reach the lower levels of the standing crops. In the third series, disturbance of the crops during spraying gave better penetration.

Table 1 summarises the desiccating effects of the 8 oz applications in the first and third series. In both, leaves of sprayed material at first dried more rapidly than the stems but

this effect was less apparent at the later stages of curing.

Spraying resulted in more rapid attainment of baling moisture content (approximately 30 per cent. dry weight basis) without appreciably affecting leaf moisture content to stem moisture content ratios of the cured material. Ryegrass was affected less than the legumes. In the third series, effects of spraying were less than those of crushing but spraying and crushing together decreased curing times more than either of these treatments alone.

Replication was insufficient for accurate comparisons of dry matter losses during curing but from the triplicate values available there appeared to be no differences between the various treatments.

Spraying caused some discolouration of both leaves and stems. The chemical changes involved might have affected palatability and nutritive value and this would need detailed investigation in larger scale tests.

Material left standing after spraying lost moisture much faster from leaves than from stems. Thus desiccation of the standing crop, as well as involving a separate field operation, would be likely to result in increased shatter losses during subsequent mowing and curing. There were no effects on subsequent growth of the parent plants when mowing was carried out either immediately after spraying or a few days later.

Conclusions

The desiccant used in these tests appreciably decreased curing times provided it was applied to both leaves and stems but effects were less than those obtained by crushing of newly

TABLE 1.

Drying times with desiccant applied at 8 oz per acre

	Lucerne			White clover			H1 ryegrass		
	Leaves	Stems	Whole	Leaves	Stems	Whole	Leaves	Stems	Whole
Initial moisture contents (% dry wt) Means for 3 series	435	455	453	480	988	691	588	631	597
First Series									
Hours to dry to 100% m.c.									
Control	64	82	72	55	94	73	—	—	42
Sprayed	15	55	46	30	74	56	—	—	40
Hours to dry to 30% m.c.									
Control	125	152	139	119	137	131	—	—	112
Sprayed	76	122	110	104	131	118	—	—	117
Third Series									
Hours to dry to 100% m.c.									
Control	31	61	50	29	71	52	33	71	50
Sprayed	20	67	46	19	79	50	21	66	47
Crushed	24	30	26	27	59	49	32	51	40
Sprayed & crushed	20	25	24	19	50	42	18	51	42
Hours to dry to 30% m.c.									
Control	57	89	76	55	90	77	53	97	81
Sprayed	52	72	60	49	83	68	50	94	77
Crushed	48	53	51	45	71	60	49	91	76
Sprayed & crushed	40	47	42	39	61	53	38	88	72
Moisture contents of standing crops 48 hr. after spraying	51	199	121	80	471	235	41	228	181

mown material. More extensive tests would be necessary to determine whether, in normal farming practice, the decreases would be sufficient to justify the expense and trouble of spraying. Spraying might have an advantage over crushing in being more convenient and involving less expensive equipment. Alternatively, spraying and crushing together might be worthwhile.

The tests reported here have at least shown that the search for a desiccant of practical value in haymaking is by no means hopeless.

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Fermentation of the Cold Dip used for Drying Sultanas

During the 1950 drying season the sultana grape crop was badly damaged by heavy rains and as a result high concentrations of grape juice or sugars were present in the bulk cold dip (Penman and Oldham 1954) which was used for hastening the drying of the fruit. In a very short time those dips containing high concentrations of grape juice or sugar began to ferment or boil. Large quantities of foul smelling gases were evolved. The dip became acid so that the oil water emulsion was broken and the dipping oil floated on the surface. In this condition the dip was no longer of any use for hastening the drying of sultana grapes and it became necessary to prepare a fresh dip.

Orton (1951) suggested that the fermentation of the dip could be prevented by adding caustic potash solution so as to maintain a blue colour with a thymolphthalein indicator paper. The pH so maintained was approximately equal to that of a freshly prepared dip, namely 11.5.

In 1955 the sultana grape crop was again heavily damaged by rain and growers were advised to prevent fermentation of their dips by adding caustic potash solution according to the recommendation formulated by Orton (1951). During their visits to growers, officers of the Department of Agriculture, Victoria, made the following observations: (a) excessive quantities of caustic potash were required to maintain a blue colour with thymolphthalein indicator paper, (b) a number of growers had been successfully dipping their fruit without adding any caustic potash and yet had no signs of fermentation.

A series of pH measurements were made on dips containing various amounts of crushed grapes to determine the exact pH at which fermentation begins so that a revised recommendation could be made. The composition of the dip used was 2 per cent. fruit dipping oil (33 per cent. sulphated butyl oleate and 67

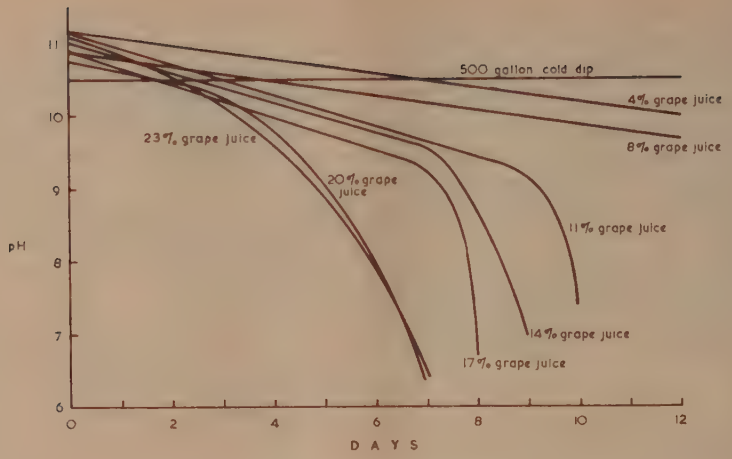

Figure 1—pH changes during fermentation of cold dip.

per cent. ethyl oleate) and 2½ per cent. potassium carbonate and corresponded to the commercial dip generally used. Three gallons of dip were mixed with various quantities of crushed grapes in a four gallon drum and left to stand at atmospheric temperature in the shade. Periodically, the pH of the dip was measured with a mains operated Marconi pH meter.

The results have been graphed in Figure 1. For all concentrations of grape juice the pH initially decreased gradually with time. This gradual decrease in pH continues until the value has been reduced to about 9.3, after which there is a rapid change in pH which is accompanied by fermentation. For the dips containing 4 and 8 per cent. grape juice the pH gradually decreased to 9.4 over a period of 48 days with no signs of fermentation. The results also show that the rate of fermentation increases with the concentration of grape juice in the dip.

For comparison, the changes in pH were determined for a 500 gallon bulk cold dip which was being used for the normal dipping of sound fruit containing a very small percentage of fruit damaged during the handling of the dip tins. These figures are plotted in Fig. 1 and it will be noted that the changes in pH are very small. It is concluded that unless large amounts of broken or badly damaged fruit are being treated there is little likelihood of the dip fermenting during the harvesting season which extends over a period of about six weeks. Nevertheless, it is advisable, especially if damaged fruit is being dipped, to check the pH periodically. To ensure that there is no fermentation the pH should be maintained at 9.5 or higher.

The exact pH at which several indicator papers changed colour was determined with the pH meter. It was found that thymolphthalein papers gave a perceptible blue colour at a pH of 11.3 to 11.7 whereas the thymolphthalein indicator solution changed colour in the pH range at 9.3 to 10.5. Phenolphthalein papers were useless and only changed colour just as the dip was fermenting. The most

satisfactory papers tested were universal indicator papers which were supplied with a colour chart graduated in half pH units. Generally these indicator papers gave a pH value 0.4 units lower than that determined with the pH meter. The indicator papers found to be the most suitable were:—

Riedel-de Haen .... pH range 9-13
Johnson .... pH range 8.4-10.0
B.D.H. .... pH range 8.5-10.0

Acknowledgments

The authors wish to thank Messrs. E. Biggs and H. Hawson of the Department of Agriculture, Victoria, for the information supplied on the operation of growers' dips.

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An Air-Pycnometer for Field Use

The measurement of soil air space is important in considering soil as a medium for plant growth. For example, air space measurements made on undisturbed core samples at field capacity indicate macroporosity, which is a major factor influencing infiltration and drainage rates, and contributing to good soil aeration and root growth. Several methods of determining the air space in undisturbed soil cores have been developed in recent years.

The method of Leamer and Shaw (1941) relies on measurements found by weighing cores drained at various tensions. This method has the disadvantage of being time consuming. Furthermore, it cannot be performed in the field.

Kummer and Cooper (1945) have described an air-pycnometer which uses the principles of Boyle's Law in its operation. The same principles have been utilized by Page (1947) in the development of a portable pressure pycnometer. In these instruments a given volume of gas at known pressure is released into the air in a confined soil core sample. The drop in pressure is a measure of the air space in the soil sample.

A slightly different principle has been used by Russell (1949). The simplified air-pycnometer described by Russell applies a known change in volume to the air in the soil sample and measures the change in pressure by means of a mercury manometer.

An air-pycnometer has been designed which uses the same principles as those of Page, and Kummer and Cooper. It was constructed to accommodate the core sample sleeves used in this laboratory for bulk density determinations.

Some new features have been incorporated in the design and it is believed to be well suited for field measurement of soil air space.

Description and Operation of Apparatus

The soil cores are taken in brass sleeves just under 0.1 in. thick, 4 in. inside diameter and

Figure 1—The pycnometer assembled for use.

2½ in. deep, in a sampler very similar to the sampler described by Lutz (1947).

The pycnometer is shown set up with a sample ring in place in Figure 1 and dismantled in Figure 2.

In operating the instrument the sample contained within the sample ring is placed on the lower plate C (Figure 3) with the brass sleeve situated centrally on the rubber inset. The upper portion of the instrument is placed on top of the sample in a similar position and bolted down tightly.

With the taps A and B turned off air is pumped into the cylinder v_1 until the pressure reads just over 60 lb/sq.in. The pressure is then adjusted to exactly 60 lb/sq.in. Tap A is opened, and the final pressure is recorded. In reading the final pressure it is important to wait until the needle comes completely to rest. When tap A is opened the gauge drops quickly to a certain point and then rises slowly by about 1 lb/sq. in. This is due to temperature effects. Once the final pressure is reached it remains steady unless the instrument is leaking.

After the pressure is recorded tap A is closed and Tap B opened. Closing tap A conserves pressure in v_1. For pumping a double action hand pump was used in the present studies, though it would be possible to use a compressed air cylinder. Care must be taken during operation to keep the plates D and C and especially the rubber insets on these plates free of dirt. If this is not done the seal is impaired, and a leak occurs which is readily detected by a continuous drop in pressure being indicated on the gauge.

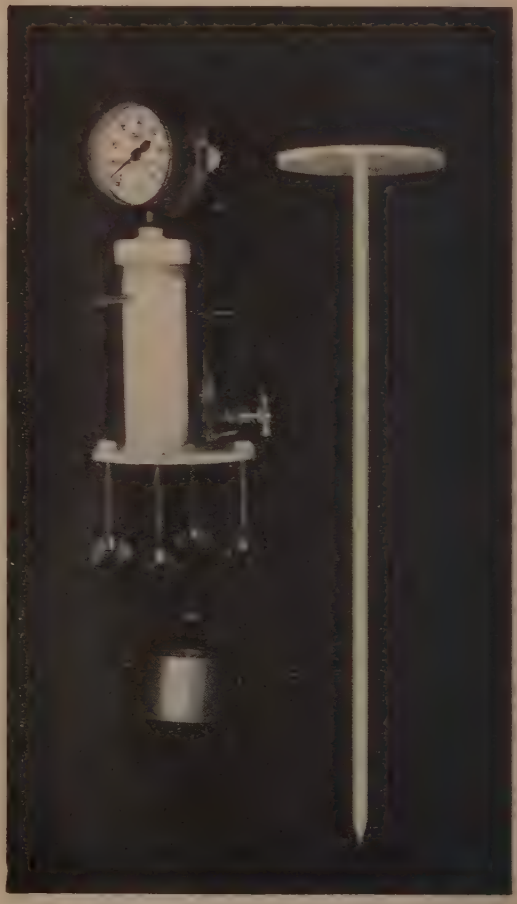

Figure 2—The pycnometer dismantled.

The final pressure is a function of the volume of air space in the soil v_2 and the volume and pressure of v_1. The value of v^2 can be calculated, or read from calibration graphs. Pycnometer readings may be used without conversion where mere comparisons of treatments are being made.

Calculations

The air volume in a soil sample is calculated from the equation:—

$$v_1 + v_2 = \frac{P_1 v_1}{P_3} + \frac{P_2 v_2}{P_3}$$

where

v_1 = standard volume of air.

P_1 = initial pressure of v_1. The pressure used is 60 lb/sq.in. + atmospheric pressure.

v_2 = volume of air in soil sample.

P_2 = initial pressure of v_2 = atmospheric pressure.

P_3 = final pressure in $v_1 + v_2$.

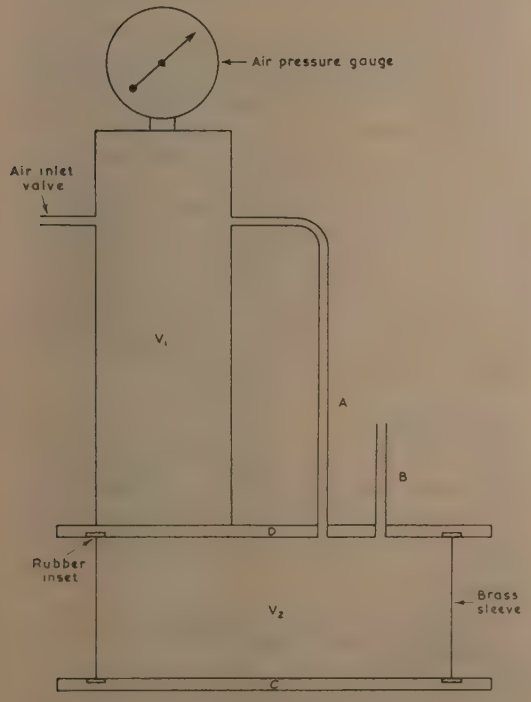

Figure 3—Diagrammatic representation of the pycnometer.

Calibration

The pycnometer was calibrated by adding known volume increments to the soil chamber and taking readings after each addition. Water was pipetted in through the air outlet tap in measured quantities and calibration curves were constructed.

The curves are shown in Figure 4. Five replicate readings were taken for every point on the calibration curves. The percentage error in readings from the mean varied from 0.55 per cent. at 35 per cent. pore space to 1.94 per cent. at 10 per cent. pore space.

The greatest range of barometric pressures likely to be experienced in the southern half of Western Australia is 28.9—30.7 inches of mercury. This range represents a pressure change of approximately 1 lb/sq. in. It is therefore possible for pycnometer readings on different days to differ by at the most 1 lb/sq. in. (which represents a volume change for v_2 equivalent to approximately 20 ccs.) due to changes in barometric pressure. Therefore unless a record of barometric pressures is kept and suitable adjustments made to readings comparisons between readings taken on different days are subject to variation.

For general purposes since the variations involved are small it is not necessary to convert all readings to a standard barometric pressure before using the calibration graph.

Field Results

The air space in a soil sample is influenced by the bulk density and the moisture content. Factors which influence pycnometer measurements but are of negligible importance are, variations in barometric pressure, temperature changes, and the solution and adsorption of air in soil under pressure, (Jamieson 1953).

In 1956 the pycnometer described here was used in the field to measure air space on 84 undisturbed soil cores from two depths in fairly uniform soil. The cores were weighed in the field and returned to the laboratory for determination of bulk density to investigate the influence of moisture and bulk density on air space. Mean values for air space as determined by the pycnometer for the two

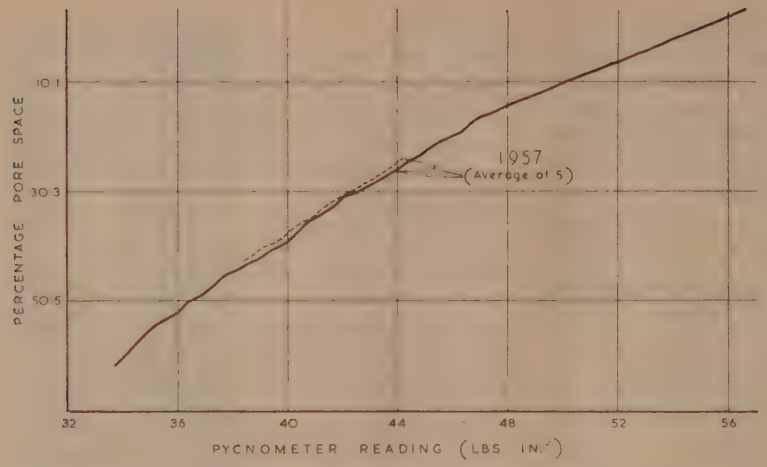

Figure 4—The calibration curves.

sampling depths used were 34 per cent. air space at 1 in.—3½ in. and 25 per cent. air space at 6 in.—8½ in. These means were significantly different, $P \leqslant 0.001$. The corresponding means of bulk density measurements were 1.50 at 1 in.—3½in. and 1.71 at 6 in.—8½ in. which were also significantly different, $P \leqslant 0.001$.

The relationships between field weight of the core, bulk density (oven dry weight basis) moisture content, and air space, as found by the pycnometer, were investigated. Air space was highly correlated with the weight of the core at the time of measurement ($r = 0.94$). Bulk density and air space measurements were also highly correlated though to a lesser extent ($r = 0.89$), indicating that bulk density variations had a greater influence on air space than other factors. The range of moisture contents was almost within 4 per cent. (10 per cent. on the dry basis) whereas the range of bulk densities was 1.35 to 1.80, (i.e., 0.45). This bulk density range represented a volume change of soil material of 80—90 ml compared with a volume change of water of about 4—5 ml for the moisture content range. The variations of bulk densities in this case therefore had a much greater influence on the pycnometer readings than the variations of water contents. In view of the predominant influence of bulk density in air space measurements, an estimate of bulk density may be made from air space figures. The primary use for the instrument is, however, in the measurement of macroporosity. This figure is of immediate interest in itself. It would be possible to measure air space at wilting point and on oven dry samples thereby obtaining figures for water holding capacity, total pore space, and soil particle density. This has not been done with the instrument.

During the use of the pycnometer it has become obvious that certain modifications would be desirable. These include fitting a pressure release valve adjustable to exactly 60 lb/sq.in. on v_1, and the replacement of the holding-down bolts by a quick fastening clamp. With these modifications it is likely that readings could be taken as quickly as core samples can be collected. It may also be an advantage to have a sample-holding chamber separate from the pressure cylinder, the two being connected by flexible rubber pressure hose.

Acknowledgment

Thanks are due to Mr. S. T. Smith, Senior Soil Research Officer in the Western Australian Department of Agriculture for helpful criticisms.

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Letters

Dear Sir,

Of the professions, it has been established by the A.I.A.S. that the Agricultural Scientist's profession is the worst paid, barring none. Starting salaries are reasonable but overall salaries are low due to lack of promotion compared with other professions. Why is there this lack of promotion? The very men who have the power to cause promotions are Agricultural Scientists themselves and members of the Institute. Why don't they exercise this power? A senior man can say "this man is doing a good job well, he should be promoted." He can repeat this often enough in the right places and the man will be promoted. The men in charge do not do this as often as is warranted, if at all; many good men have to wait for normal slow advancement at the same rate as the plodders.

Why don't senior men help their men up the ladder?

Too often they cannot truthfully say a man is doing a good job because this man is not given a chance to do so. Responsibility is withheld and decision making discouraged. If a man is given responsibility early, he will do a better job, he will be proud of his job and will strive to do better still.

Too often the senior officer cannot say a man is doing a good job because he doesn't know. His man is discouraged and prevented from showing that his work is good. Reports, memos, letters and articles often have to be written over the name of his senior! A man in such a position cannot be recognised for his work.

Often, a professional officer stationed in the country does a job worthy of a greater salary than the senior men at the city office—if intensity of effort and results could be used as a basis for determining personal reward. The country officer's efforts go unnoticed and unrewarded.

A feeling of inferiority in the senior man can prejudice the opportunity of a good graduate officer. This is difficult to prove or illustrate, but it must happen, and the indications are that it indeed does. After all, academic background must improve through the years, the Agriculture degree has more behind it than before. The older men must lose touch and they should use the new knowledge coming in to the full. It is easy, very easy to keep ahead of ones staff by holding them back. As there is much evidence to suggest that this does happen, senior men must ask themselves whether they might be contributing to the poor status of Agriculture today.

If improved opportunity improves the prospect for agriculture, graduate numbers will increase in the long run, and the profession should expand, to the benefit of the industry. Senior men can handle the extra only if they learn to delegate responsibility.

Yours, etc.,
B. a'B. MARSH.

Department of Agriculture,
W.A.

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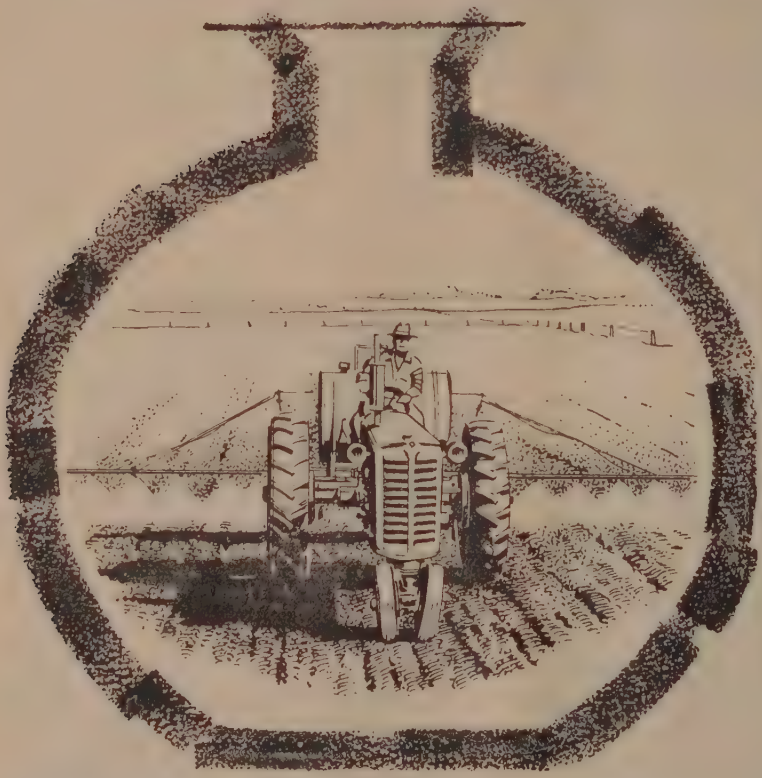

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Talks

The Role of Breeding in Improving the Efficiency of Australia's Wool Industry

Miss Helen Newton Turner, Animal Breeding Section, C.S.I.R.O., Sydney

The efficiency of an industry may be described broadly as amount of production per unit of cost, in terms of initial and annual expenditure of money and labour. Breeding plans can be used in many ways to increase efficiency, but a first essential is a clear definition of production. The number of characters included in the definition should be kept to a minimum, since progress in any one will obviously be less when others are included.

For the wool industry, the main gauge of production at present is money return for raw wool, though numbers of lambs and quantity and quality of meat are also involved. As the final product is textile yarn or fabric, the overall efficiency of the industry might be improved if the sheep-breeder thought of his returns in terms of quantity and quality of yarn or cloth, rather than in terms of raw wool. This requires more specific information than is at present available concerning the characteristics of the raw wool which influence the amount of waste in textile processing, but research which is now in progress may provide some of the required information.

Whatever the final criterion of production, both quantity and quality of wool are important. Quantity is measured directly as clean wool weight, and although wool production per acre or per unit of food may finally have to be considered, clean wool weight per head will always be of considerable importance. Quality is not easily defined; of the many characteristics which contribute to it, average fibre diameter is considered of greatest importance, but, as this is not readily measured, it is commonly assessed in the trade through the number of crimps per inch of staple. Although there is a strong negative correlation between crimp number and fibre diameter when a wide range of wools is considered, there is now considerable evidence that crimp is not a good guide to diameter for individual flocks. This is an indication to the breeder that he should at least know what the relationship is in his own flock.

For the present, it is likely that spinning count, assessed mainly on crimp number, will continue to be the main criterion of quality. What, then, can be said about the use of breeding plans to raise clean wool weight per head while retaining quality?

Breeding plans can be considered under two main headings—plans for individual flocks and plans for the industry as a whole—each of which can be further discussed under the three headings of selection, mating systems and flock (or industry) structure.

For individual flocks, the choice of selection method and mating system depends largely on the heritability of the characters concerned. For fleece weight and associated characters, the heritability value is high, so that selection of individual animals on their own performance is sufficient without the added expense of measuring relatives, when selecting from a group reared together. Mating systems can also be simple without the added expense of more complex methods.

Selection experiments carried out by C.S.I.R.O. at the National Field Station, Cunnamulla, Queensland, have confirmed the prediction that direct selection of individual animals on their own clean wool weight will lead to a rapid response. The average fleece weight of the selected group has drawn steadily away from that of an unselected control group run with it, until now, at the end of eight years, the average clean wool weight in the selected group is one pound more than in the control. The increased weight comes mainly from a greater number of fibres per square inch of skin and a longer staple. Fibre diameter, which is controlled by rejecting animals with a high value, has not changed. There has however been a slight fall in crimp number, and the importance of this is being investigated by processing fleeces from the two groups. Animals in the selected group have not changed in size, and food consumption was the same in samples of animals from both groups which were pen-fed. Death rates and fertility rates in the selected group are so far the same as in the control. Direct selection for fleece

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This talk and the five following talks were given to the Symposium, Science and the Efficiency of Australia's Wool Industry, organized by the New South Wales Branches of A.I.A.S. and A.S.A.P.

Mr. R. B. McMillan's talk, Wool in the World Market and in Australia's Economy, is published in the Review Section of this issue.

weight therefore offers one immediate avenue of improvement which can be obtained at low cost.

Selection in relation to the industry as a whole is concerned with finding the right animal for the right environment. A large C.S.I.R.O. experiment, in which five strains of Merino were run in three environments, showed no special adaptations, except for the incidence of fleece rot. If a breeder is in an area where fleece rot prevails, it can be avoided by choice of a resistant strain.

Although no specially-adapted strains were found among those tested, this does not mean that they cannot be developed, and to investigate this another experiment is in progress, in which a comparison is being made of the progeny of the same rams, grown in different environments. There is some evidence suggesting that a ram whose progeny are the best in one environment may not be best in another. If this happens often, then ram-breeding studs should be scattered in a variety of environments, instead of being kept in the better ones.

The existing stud structure, with its well-developed parent and daughter studs, is, however, the most economical way of introducing genetic improvement into the whole industry, provided the studs are using the right methods and are making genetic progress.

Most sheep-breeding research in Australia has previously been devoted to wool production. Fertility and meat production are now receiving attention, and the response to selection for twinning rate has been much greater than was expected.

The progress which can be achieved through breeding may not be as spectacular as that which follows improvement in nutrition. Genetic improvement has nevertheless been demonstrated to be appreciable. It can usually be obtained at a lower cost and in a wider range of environments than the more dramatic increases which may accompany such measures as pasture improvement.

The Role of Animal Husbandry in Improving the Efficiency of Australia's Wool Industry

Dr. G. R. Moule, C.S.I.R.O. Sheep Biology Laboratory, Prospect, N.S.W.

It is difficult to define the efficiency of the sheep industry in terms of pure economics. It seems more reasonable to gauge efficiency on the degree of development of the natural resources, in country used for sheep raising, and on the present production compared with the potential.

What contribution can animal husbandry make to improving this efficiency?

In dictionary terms, animal husbandry covers the breeding, feeding, and management, of farm animals; but its present usage covers the application to animal production of sciences ranging from genetics to physiology, nutrition to veterinary medicine, from economics to agronomy and ecology; and of great importance in this country, it covers the interaction between the sheep and the diversified environments in which it is raised.

In terms of development and husbanding of the natural resources of country used for sheep raising, the agronomic aspect of animal husbandry has done much, particularly through ley farming in the wheat-sheep zone and pasture improvement in the higher rainfall zone.

The comparison of the present with the potential production is difficult because of the wide variation in productivity throughout the country. It is however significant, that only in Tasmania has there been a consistent increase in lamb marking percentage in recent years, although pasture improvement is increasing rapidly in other States. Obviously, management practices have not kept pace. Over 50 million ewes are mated in Australia annually but about 30 per cent. do not raise a lamb. If the known principles of animal husbandry were applied to breeding flocks then it is estimated that as many as 10 million additional lambs could be reared annually.

Animal husbandry is too often thought of as disease control alone, but great increases in productivity may still be obtained in healthy flocks. Thus in a Queensland selection experiment, it was shown that by selection of the more efficient converters of feed to wool, production could be lifted from 4.0 lb of greasy wool per acre to 5.3 lb, i.e., an increase of 40,000 lb of wool on an average property in central western Queensland.

Animal husbandry has, however, done a great deal for the sheep industry in terms of veterinary medicine, e.g. carbon tetrachloride drenching of sheep infested with liver fluke. Nevertheless, many of the diseases which can be cured, can also be prevented, but too often the preventive measures are overlooked, e.g. eradication of the fluke carrying snail by bluestone treatment of swamps. Frequently too, the value of the Mules' operation for reducing blow fly strike is not appreciated, yet losses through this scourge, have amounted to millions of pounds.

While an animal's potential is set by its inheritance, the extent to which it obtains its potential depends on the way it is fed and managed and the limits imposed by its environment. Thus adequate feeding in late prenatal life and during growth can markedly reduce adult wool cuts, undernutrition at these critical stages is all too frequent.

It must be concluded then that animal husbandry can do much to improve the efficiency of the sheep industry, but that the industry must shoulder its responsibilities in the application of existing knowledge.

The Role of Pastures in Improving the Efficiency of Australia's Wool Industry

Mr. W. M. Willoughby, Agronomy Section, C.S.I.R.O., Division of Plant Industry, Canberra.

Over most of the wool growing areas of Australia the efficiency of conversion of the land and climatic resources into animal products is at low levels. In the regions of low and unreliable rainfall there may be little or no alternative to this situation, but in the better watered regions—where possibly more than 60 per cent. of the sheep population is located —substantial improvement is possible. Low efficiency over the greater part of these latter regions can be broadly ascribed to one or more of the following causes:—

Low Efficiency of Conversion of Land and Climatic Resources into Plant Material

In the main this is due to inadequate soil fertility, a limitation which in many areas can be readily alleviated by the use of clovers and fertilizers. However,

A. The major proportion of the potential area is still completely untreated.

B. A large proportion of the treated area is still only in the initial stages of soil fertility improvement. Consequently clover dominance is common and the attendant danger of ewe infertility and other sheep problems is high.

C. In many of the areas where soil fertility has been appreciably raised the enhanced nutrients in the soil are being absorbed by undesirable plants rather than species which can make optimum contribution to animal feeding.

Low Proportion Consumed

Though enhanced soil fertility allows greater pasture growth in the troughs or limiting periods of pasture availability, thereby enabling more stock to be permanently supported, it also provides greater surplus in the peak periods. Only a small portion of the annual pasture growth is consumed. The only way to use more of this surplus is to have still more stock and to take the following measures to support them in times of shortage:—

A. Provide adequate drought reserves.

B. Adjust breeding times so that as near as possible the expected periods of pasture shortage coincide with periods when sheep intake can be depressed with least harm, and so that the expected periods of pasture surplus coincide with periods when sheep intake is at a maximum. Some manipulation of pasture usage is possible in many circumstances to more closely achieve this coincidence.

Low Efficiency of Conversion

Miss Turner has outlined the contribution which animal breeding is making towards the selection of sheep which give greater wool production per head per unit of food consumed. Selection of plant type to give greater wool production per head per unit of the material consumed also has fruitful possibilities. However, investigations towards this end are complicated by the innumerable factors in the field influencing the quantity and type of material voluntarily consumed by the sheep.

In summary the major factor determining wool production per property is the number of animals which can be permanently supported. Production per head is of secondary importance. High animal numbers depend on high soil fertility, maximum provision for drought, and the adjustment of breeding times and pasture usage to achieve the best fit between pasture supply and essential animal demand. Evidence in this direction has been obtained from pilot property experiments and is being confirmed by a few graziers in widely separated locations.

Wool and the Textile Manufacturers

Mr. W. R. Lang, Head, Textile College, Gordon Institute of Technology, Geelong.

The woolgrower tends to think in terms of wool on the sheep, or on the classing table, or in the bin classed and ready for baling, or overflowing from the bale on the showfloor. In either of the last two, he is looking at wool in the same form as it will be seen by the manufacturer, but he views it rather as the culmination of his husbandry effort with individual sheep or the flock. The woollen and worsted manufacturer sees wool as bulks of somewhat variable raw material, from which must be spun the yarn needs of his mill. His major attention is directed towards the end-products of manufacturing. He is interested in the bulk, not in its parts. He is concerned with the bulk as a means to achieving the yarns necessary for his final product. He is worried by the need to maintain his standard bulks constant from year to year. Each manufacturer has 4 or 5 main bulks, as a rule, from each of which he makes a small number of standard yarns. The demands of fashion will not affect the basic yarns, so much as the weave, set and colour of the fabric, as well as the structures of fancy yarn. Different manufacturers will have different standard bulks, but the individual will usually seek a few bulks as a source for a small number of basic yarns. Immediately he commences processing, he sets to work to homogenize the bulk, to disintegrate the staples and fleeces on which so much care has been bestowed in animal husbandry. He seeks a thorough intermixing of the fibres, because he is the "great averager."

To a manufacturer, a 64's good quality, worsted length merino wool may be spun to a nominal 64's, i.e., to 64 hanks of 560 yards length per lb of worsted top, but this would be the limit of its performance. There would be so many thread breakdowns in spinning to a higher count that a spinning limit would be indicated by the inability to spin. In practice 64's from a 64's is a rarely sought ideal, because such spinning is slow, costly and would not suit most orders. 64's wool would rarely be spun to better than 48's and it would not be surprising to see it being spun to 10's, for certain tasks. Because the wool manufacturer usually spins well within the capability of a wool, he can only give a general guide to wool performance. Most of his observations are known to the woolgrower in the form of the price differential paid in the market. That this is sometimes confusing reflects changes in trade and uncertainty in manufacturer's mind. Furthermore, he does not reveal all he knows.

This emphasises the need for a more explicit arbiter in the person of the research worker, who must take extraordinary care to match comparison wool bulks in all characters except one, and then by processing, learn the effect of this. For this reason information is gathered slowly.

In any wool there are two main factors, which control the technological performance, namely, the intrinsic properties of the fibre substance, and the properties due to fibre dimensions, form and surface.

The cell structure of the fibre suggests heterogeneity, because there are at least three layers in the cuticle and the cortex is formed from fibril embedded in a matrix within a cell membrane, the cross section containing several cells. The fundamental molecular structure of wool is folded, i.e., alpha-keratin, when at rest and unfolded, i.e., beta-keratin when sufficiently stretched, a transition unique to the mammalian hairs and rubber. This wool substance is markedly affected by moisture content, and by the various sets, either cohesive, temporary or permanent, which are imposed by strains at ordinary temperatures in the dry, in hot water, or in steam. For some time, evidence appeared to favour the view that wool substance is reasonably constant in the Merino and near-Merino types. Speakman and his colleagues at Leeds first emphasised that there were plasticity differences between the two main groups of fibres in the N.Z. Romney fleece, the Primary and the Secondary, and recently is reported as indicating differences which are also evident to the manufacturer and are made use of for special purposes of manufacture.

As far as the dimensional traits are concerned, fibre fineness is of great significance in the mechanical properties of the fibre. Fibre length decides the purpose of a wool. Recently the research of Menkart and colleagues has found that change of staple crimp frequency appears to have only a small effect on spinning efficiency, as well as on the physical characters of yarn and fabric. The slightly better performance is associated with the higher crimp frequency. In Geelong we are studying the manufacturing performance of normal and doggy

wools from the same flock. The doggy which should have much less crimp and a shallower wave, has spun surprisingly well and is only slightly inferior to the normal. This work is proceeding.

In summary, it has become evident that the manufacturer can only give general answers to many of the questions that the woolgrower wishes to ask. The research worker is providing and will provide much more explicit information but this will take time.

Improvements in Processing Wool in a World of Modern Textiles

Dr. M. Lipson, Chief, Division of Textile Industry, C.S.I.R.O., Geelong.

The world textile supply position was discussed with emphasis on changes which have taken place in the past twenty years. Cotton is still the major fibre, wool still represents about 10 per cent. of textiles whilst the synthetics which were not in production twenty years ago, now represent about 4 per cent. of total supply. The increased production of synthetics in this period is very similar to what took place with rayon about thirty years ago and if the present rate of increase continues, the output of synthetics could pass that of wool within the next four years.

Wool has some major advantages when compared with synthetics. In particular, its high moisture absorption results in less static electricity and soiling as well as greater comfort in wear. The synthetics have advantages in dimensional stability in fabrics and the ability to take a permanent crease due to their thermoplastic nature. Wool textile research is designed to meet the challenge of synthetics by overcoming disadvantages of wool in competition with them. For these reasons, problems such as shrinkproofing, permanent pleating and mothproofing are being closely studied. A method of mothproofing based on Dieldrin is now used in most major Australian mills and has extended to other countries. Mothproofing should not present a great problem to users of wool in the future. Research on shrinkproofing is producing new methods and it is anticipated that in the near future, shrinkproofed wool will be more widely available than hitherto. The Si-Ro-Set process for permanent pleating and creasing of wool has been used to date on about 800,000 pairs of trousers in Australia and has now been taken up in other major wool using countries. Research is now being carried out to develop washable non-iron effects on pure wool and encouraging results have been obtained in this field.

Research on wool textile processing is designed to overcome weaknesses associated specificially with wool. For this reason, fields such as scouring, carding and combing and worsted drawing have been closely studied. A solvent degreasing method for cleaning raw wool has resulted in better processing performance. A comb control unit for electrical control of the Noble comb has been recently developed and is now being installed in industry. Two outstanding developments in Britain are the Raper Autoleveller and Ambler Superdraft for use in shortening the number of steps required in worsted processing.

The Importance of Wool Marketing

Mr. A. G. Lowndes, Chairman, Australian Institute of Political Science.

Proposals to change the free auction system of wool marketing invariably come forward when prices are depressed. Thus, there has recently been much talk about a change in the system. The reason was primarily that average greasy prices had fallen to 46d. which is unprofitable for most producers. If the price were to rise again to above 70d. the agitation would almost certainly disappear.

Many of the arguments for change as put forward by spokesmen of producer organizations, seem rather unconvincing. The main argument seems to be that the price is too low, implying that a change in marketing would rectify this. Wool producers also see many other primary products with some form of organized and controlled marketing and they seem to think that something of the kind might help them in a period of low prices. It seems most dangerous to draw analogies with other primary products where such factors as supply, the nature of the product and possibilities of controlling production to meet demand, all create very special conditions.

It is conceded that there may be new factors affecting wool which call for closer study of marketing methods. One is the increasing importance of synthetics which offer many attractions to manufacturer and retailer. It can be argued that this factor can best be met by better promotion of wool, and some improvement in methods of classing and handling. The growers themselves, through the Wool Bureau which they control, should take a more realistic approach to the future for wool in blends with synthetics. Instead, they refuse to do anything about the possibilities in this direction, apparently hoping for some miraculous development in wool processing which will eliminate much of the competition from synthetics.

The alternatives to the auction system which receive most publicity are a floor price scheme or an appraisement scheme with bulk handling and marketing.

Floor price schemes are in operation in New Zealand and South Africa. However, producers in those countries do not appear to have fared any better than Australian woolgrowers in the recent recession in prices. There have also been some factors about the operation of these schemes which would be unfortunate if applied to Australia. The main weakness of these schemes is that the reserve price has to be set so low that it is ineffective in sustaining prices. If the management of the scheme stands out against market trends, then they must accumulate stocks which later delay recovery in prices. Very large funds are required to operate on an adequate scale.

The main objection to an appraisement scheme of the type which operated during the war is that it involves the creation of a bureaucracy with centralized responsibility for judgment and decision. For better or for worse, most growers in the past have preferred to accept the risks of the auction system and a free market.

One problem in assessing the desirability of any change is that there is no clear-cut agreement among growers as to what they really want. Is it only to avoid troughs in the price graph but to retain the occasional peaks? Or would they accept a stabilized system which sought to avoid both peaks and troughs?

While the growers' organizations are sorting out some of the confused thinking which appears in their public statements on the subject, a great deal might be done by pursuing many relatively easy methods of improving some details of the present marketing system, of the handling of wool after sale and of the promotion of its use. Personally I consider that there is great scope for improvement in these directions and that such improvements would be more valuable than any major departure from the present auction system.

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News Items

Wool Research Station for Northern Territory

In conjunction with the Department of Territories and the Northern Territory Administration, C.S.I.R.O. is establishing a new Research Station on land adjacent to that being used by Territory Rice Limited for rice production at Humpty Doo. The long-term objective will be to investigate the agriculture potential of the coastal plains of the Northern Territory, while the most immediate problems to be investigated will be directed towards the production of rice. It is envisaged that rice will be the main crop of this area, but the Station will look towards other forms of land use in due course.

Mr. K. Wilson-Jones has been appointed Director and will be arriving in October. In the meantime, Mr. D. Moir has been doing the pioneer work in establishing the Station. The Station will be part of the network of Stations throughout the North operated by the C.S.I.R.O. Division of Land Research and Regional Survey.

More New Buildings

The third of the new office buildings for the Western Australian Department of Agriculture is approaching completion, and it is expected that the last of the professional branches will move in early next year. This building will be occupied mostly by the Animal Division.

Wagga and District Rural Service

An organization known as The Wagga and District Rural Service was formed at a public meeting in Wagga on June 19, on a similar basis to the Bombala District Rural Advisory Service and the Farm Improvement Clubs in New Zealand.

The constitution of the service provides for a maximum membership of 50 primary producers who will pay annual subscriptions varying on a graduated scale with the size of their properties from £50 for areas up to 1,000 acres to £140 for those of 5,500 acres and above. The funds will be used to employ an agricultural adviser and meet his travelling costs plus general administrative expenditure.

A Board of Management is to be elected annually to control the activities of the service and a novel feature of the organization is that all secretarial work and administration will be carried out by a commercial firm, the Riverina Spraying Service, whose manager, Mr. A. C. Sundstrom, will be Secretary to the Board.

Similar clubs are in process of formation at Moree, where a provisional committee was appointed at a public meeting in May, and at several centres in the New England region.

The New South Wales Branch discussed the farm improvement club movement and the general subject of agricultural consultants at a symposium in Sydney on July 31.

New Veterinary Professor at Sydney

Professor David McFarlane, has been appointed to the Chair of Veterinary Medicine at the University of Sydney. The Chair was originally called the Chair of Veterinary Science, but was changed on Professor Gunn's retirement.

Professor McFarlane graduated from the Glasgow Veterinary College and was awarded the degree of B.Sc. with first class honours in Pathology and Bacteriology. He obtained the coveted Beil Memorial Fellowship at Cambridge and from 1942-47 was Senior Lecturer in charge of the Department of Pathology at the Royal Veterinary College in Edinburgh.

In 1947, he took up the position of Chief Diagnostic Officer and second Officer-in-Charge at the Animal Research Station at Wallaceville in New Zealand; he was in charge of all the diagnostic work in the Dominion. His interest then changed to field aspects of pathology and in 1952 he transferred as Officer-in-Charge to the large Veterinary Club at Gisborne, where his work on lamb losses became well-known. He remained at Gisborne until taking up his present position.

C.S.I.R.O. Prospect

July has been an important month in the history of Prospect Laboratory because for all practical purposes it has seen the completion of the main laboratory building. Research workers who have been appointed to the Laboratory during the seven years from 1953 and who have suffered considerable overcrowding are now moving into their new quarters. The laboratory staff now consists of 43 professional workers classified as Research and Experimental Officers and the total staff amounts to 141.

Two new fields of work have recently been opened up at the Laboratory. Firstly, Dr. Norman Graham, formerly of the Hannah Dairy Research Institute in Scotland, has set up closed circuit apparatus for calorimetric studies of energy metabolism in sheep. This work will supplement that which has been in progress for many years in Adelaide at the Laboratory of the Division of Biochemistry and General Nutrition, C.S.I.R.O. This fundamental work is vital for an accurate assessment of the nutritional and dietetic aspects of improving sheep husbandry. It may well provide key essential knowledge for improving the husbandry of the pregnant ewe.

Secondly, officers formerly with C.S.I.R.O.'s Isotope Chemistry Section in the Chemistry School of the University of Melbourne, are now located at this Laboratory. They are actively collaborating with physiologists and biochemists in applying isotope labelling techniques to problems of sheep physiology and biochemistry. In recent weeks this group has conducted a school for research workers of C.S.I.R.O.'s Division of Animal Health and Production in which the potentialities and limitations of these techniques were brought to the attention of specialists in many fields of animal production.

Wool Production and Marketing

Current interest in wool production and marketing has caused several organizations to hold public meetings on the subject.

On June 4, the New South Wales Branch of the Institute conducted a very successful symposium with the New South Wales Branch of the Animal Production Society entitled, Science and the Efficiency of Australia's Wool Industry. Papers are summarized elsewhere in this issue.

In July the Australian Institute of Political Science held its annual winter school on Australian Wool Marketing. The three main subjects discussed were:—The Present Situation of Wool in Australia—The Present Australian System of Marketing Raw Wool—and Alternative Marketing Methods.

Finally, in August, the School of Wool Technology, University of New South Wales, held a full two days' series of special lectures in wool commerce, in which the marketing of raw wool and its handling and treatment by the trade and by the manufacturer were discussed at some length. Potash usage exceeded 40,000 tons for the first time in Australia last year.

Potash Fertilizer Figures

The following figures show the combined tonnages of muriate and sulphate of potash used in each of the calendar years 1956 to 1958:—

	1956	1957	1958
Fruit (temperate)	4,742	5,238	5,120
Fruit (tropical)	3,379	3,407	4,357
Market Gardens	3,218	3,551	3,660
Potatoes	2,490	3,577	3,785
Sugar Cane	11,056	12,539	13,780
Tobacco	569	582	1,234
Pastures	5,516	9,368	11,431
Home Gardens	257	344	446
Other Crops	447	676	510
Industrial	233	358	234
Total	31,907	39,640	44,557

The greatest increase in usage has been on pastures. Since 1952, the use of potash on pastures has risen from 196 tons to 11,431 tons.

Muriate of potash was the most widely used of the potash fertilizers, a total of 39,320 tons being used throughout Australia as compared with only 5,237 tons of the sulphate.

Quantities of potash fertilizers used in each State during 1958 were:—Queensland 20,028 tons, Victoria 11,398 tons, Western Australia 5,211 tons, Tasmania 3,046 tons, New South Wales 3,004 tons, South Australia 1,870 tons.

Study of Kangaroos

The red kangaroo is the next target for C.S.I.R.O.'s Wildlife Survey Section. It will make a thorough

study of the habits of the red kangaroo to find out ways of controlling it economically.

The build up of red kangaroos to plague or near plague levels is causing concern to graziers in many parts of inland Australia and particularly in western New South Wales.

In studying the habits of these animals C.S.I.R.O. will use the techniques developed during its recently completed four-year survey of the euro or hill kangaroo in north-western Australia.

The present project will include investigations into the animal's water requirements, drinking habits, diet, food preferences and the extent of its wanderings. Aspects of reproduction and the potential and actual increase of population will also be studied.

These investigations will inevitably be long-term in character and will combine extensive surveys with intensive observations on a selected study area.

Work on Euros

Four years of work in the north-west of Australia has provided detailed information on the euro or hill kangaroo. This active marsupial, a little larger than a wallaby in size, has been marked down by pastoralists as a major pest. They have blamed it, along with other vermin, for the degeneration of native pastures in the north west.

The survey indicates that sheep are the main cause of pasture damage, but the euros assist them in eating out the native grasses. Because of this, a campaign to reduce euro numbers will often be justified.

In this work special attention was given to water poisoning which provides the most likely method of control of the euro.

C.S.I.R.O. worked in close association with the Western Australian Department of Agriculture. Investigations were carried out by Mr. E. H. M. Ealey of the C.S.I.R.O. Wildlife Survey Section who spent four years with his assistants at the abandoned Woodstock Station near Marble Bar, W.A.

The Woodstock observations showed that euros drink very little. Even in the height of summer many animals go for more than five days without a drink.

The survey indicates that poisoning should only be carried out in hot, dry conditions and should be carried on for at least six days at a stretch.

Clearing stock from areas for rotational grazing would enable poisoning of waterholes to be carried out safely and for long periods.

Results also indicate that if euro numbers in an area are drastically reduced by poisoning, numbers are not likely to build up by migration from adjoining areas. The euros would need about 10 years to restore their numbers again by breeding.

C.S.I.R.O. Division of Tropical Pastures

The formation of a Division of Tropical Pastures with headquarters in Brisbane has been announced by C.S.I.R.O. The new Division, which is the first in Queensland, has recently moved into the new Cunningham Laboratory at St. Lucia. Dr. J. Griffiths Davies, formerly Associate Chief of the C.S.I.R.O. Division of Plant Industry, is the first Chief of the Division.

The main work of the new Division is the replacement and supplementation of the low quality native pastures with improved pasture and fodder crops. A number of productive and climatically adapted pasture grasses for the Queensland subtropics is available, but the generally infertile soil conditions prevent their exploitation in sown pastures. The most important soil deficiency is nitrogen, but phosphate is also limiting and deficiencies of potassium, sulphur, copper and molybdenum have also been found.

The Division's work on the correction of nitrogen deficiency includes strong efforts to find suitable pasture and crop legumes and adapt these to climatic conditions in northern Australia. A comprehensive study of the nitrogen status of soils and plants and the utilisation of nitrogen fertilisers by pasture grasses is being undertaken also.

Rockefeller Grant to C.S.I.R.O.

The Rockefeller Foundation has given 30,000 dols. to the C.S.I.R.O. Division of Tropical Pastures for special equipment for soil fertility, plant nutrition and nitrogen metabolism studies. The equipment to be purchased includes a mass spectrometer, an automatic Moore and Stein apparatus and automatic counting and monitoring equipment for studies using radio active elements.

The new equipment will be used to expand the Division's work on nitrogen and phosphorus which

are the most important nutrient deficiencies in Queensland soils.

Research projects in nitrogen using N15 will cover several aspects of nitrogen accumulation, transfer, and loss in soils under tropical conditions. The work on the metabolism of plant nitrogen includes studies of the assimilation of nitrogen, its conversion into amino acids, and the synthesis of protein in tropical plants. P32 will be used in investigation of the availability of phosphate in tropical soils and the uptake of phosphorus by pasture plants.

New Cunningham Laboratory

The new C.S.I.R.O. laboratory next to the University of Queensland at St. Lucia, Brisbane has recently been completed. The laboratory which is named after Allan Cunningham the pioneer botanist and explorer, provides a permanent home for the Division of Tropical Pastures and also houses a regional research group of the Division of Soils. The building cost £170,000 and the Queensland State Government provided the four acre site and £25,000 towards the cost of construction.

The new building has a floor area of 29,000 square feet and consists of a main floor housing laboratories and administration with a basement underlying the northern half housing service areas for glasshouses, garages and workshops and comprehensive facilities for handling plant and soil samples.

Laboratory accommodation for the Division of Tropical Pastures provides for three groups of regional agrostologists and for workers in plant breeding, nutrition, ecology, chemistry, physiology and legume bacteriology.

The area accupied by the Soils Division includes soil fertility, soil chemistry, and soil physics laboratories, and a drawing office for survey workers. General facilities include administrative offices, a meeting room, and library.

The four separate constant temperature rooms with independent control, are a special feature, and there are three glasshouses with a total floor space of 4,200 square feet. A new glasshouse for soil fertility will be built this year, with provision for controlled environment equipment for plant physiology experiments.

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Personal Notes

Australian Capital Territory

Dr. D. L. Hayman is leaving Canberra to take up a position in the Genetics Department of the University of Adelaide.

Mr. R. W. Wilson, first Assistant Secretary of the Department of Primary Industry is going to the Agricultural Development Section of the International Bank, Washington D.C. for a three-year period. He will work with Mr. P. Reid a fellow Australian and a member of this Institute.

Mr. W. D. Hardy, of the Department of Primary Industry has been appointed as a member of the Australian Film Board.

As mentioned in the last issue *Mr. R. Slatyer* is leading a Training Course in Arid Zone Climatology in Pakistan. He is now developing this trip into a tour around the world, a highlight of which will be attendance at a UNESCO Symposium on Plant Water Relations in Arid Regions. This symposium will be in Madrid.

Mr. L. G. Wilson, previously Assistant Technical Secretary of the C.S.I.R.O. Division of Plant Industry has returned to the organisation's Head Office in Melbourne to assist Mr. G. B. Gresford.

Mr. F. Bennett, who was previously Assistant Director of Parks and Gardens, Department of the Interior, A.C.T., has spent some time with the New Zealand Department of Agriculture. He has now decided to return to Australia to accept a position as a Research Officer with the Bureau of Agricultural Economics.

Mr. R. Sherwin is returning from Washington to the Bureau of Agricultural Economics. Whilst in Washington he was Agricultural Attache at the Australian Embassy.

New South Wales

Dr. H. J. Hynes has been appointed Director of the N.S.W. Department of Agriculture following the recent retirement of Dr. R. J. Noble. Dr. Hynes was one of the four N.S.W. delegates who finalized with other States the Institute Constitution in January, 1935, and was elected Foundation Journal Editor. He was editor till 1941.

Mr. L. Balaam, a Queensland member, has been appointed Lecturer in Agricultural Biometrics at the University of Sydney. He was formerly with the Queensland Department of Agriculture and Stock.

Mr. H. J. Willetts has recently joined the Staff of the New England Experiment Farm at Glen Innes. Mr. Willetts, a Plant Pathologist, obtained his M.Sc. at Bristol University in 1954 and is at present engaged in research on blue mould of tobacco and on nematodes attacking tobacco in northern New South Wales.

Mr. P. M. Guerin has been appointed agronomist in the N.S.W. Department of Agriculture at Glen Innes as Plant Breeder specializing in Oats and Linseed. Before coming to Australia Mr. Guerin was employed in Ireland in the Department of Agriculture Dairy Farms Survey, and teaching in an Agricultural College. He has also been a scientific assistant on the staff publishing *Field Crop Abstracts* and *Herbage Abstracts.*

Mr. W. J. Greenhalgh, of the Dept. of Agriculture and former Treasurer of the N.S.W. Branch has been transferred to Bathurst Experiment Farm to carry out horticultural research.

Mr. D. B. Muirhead, of the C.S.I.R.O., has been sent by the Australian Meat Board to study the marketing of Australian meat in the United States

Victoria

Mr. W. R. Jewell, Chief Chemist of the State Government Laboratories, retired during July. Mr. Jewell first joined the Department of Agriculture

in 1926 as Officer in Charge of the Chemical Laboratories. In 1932 the Laboratories of the Departments of Health and Mines also came under his control.

Mr. Jewell has held high office in the Royal Australian Chemical Institute and has served on many technical committees on widely divergent subjects. His capable administration placed the State Laboratories on a high technical plane.

Mr. R. E. Loder has been appointed Melbourne Manager for Grazcos Pty. Ltd.

Mr. G. W. Hexter, formerly District Agrostologist of the Department of Agriculture at Euroa, has joined Commonwealth Fertilisers & Chemicals Ltd.

Professor H. C. Forster & Dr. D. B. Williams are members of a committee which is at present investigating the agricultural potential of the Northern Territory.

Mr. R. Sloane has been appointed Horticulturist with the Imperial War Graves Commission.

Queensland

Dr. W. A. T. Summerville, Deputy Chairman of the Sugar Experiment Stations Board, attended the 10th Congress of the International Society of Sugar Cane Technologists in Honolulu in May. Also at this Congress was *Mr. R. W. Mungomery* of the Bureau of Sugar Experiment Stations who visited Taiwan before the Congress to inspect its sugar industry and research establishments.

Mr. L. Balaam, Biometrician, left the Department of Agriculture and Stock to take up a lectureship in Biometrics in the Faculty of Agriculture of the University of Sydney.

Dr. G. Alexander, of the Cattle Husbandry Branch of the Department of Agriculture and Stock returned in June from Oregon State College where he was awarded his Ph.D. for studies on the biochemistry of large animal genetics. His thesis was entitled "The Relation of Serum Phosphatases to Growth of Genetically Different Groups of Beef Cattle."

Mr. D. S. Teakle, Plant Pathologist of the Department of Agriculture and Stock, Nambour left for Berkeley, U.S.A., in August, to take up a research assistantship for three years at the University of California.

Dr. P. J. Skerman was awarded a M.B.E. in the Queen's Birthday Honours List for his contribution to the development of agriculture in Queensland.

Mr. R. Humphries has been appointed Chief Agrostologist in the Department of Agriculture and Stock.

South Australia

Mr. W. B. McGlasson, of the Horticultural Branch, Department of Agriculture was recently awarded a Rockefeller Travel Grant to enable him to take up a Research Assistantship in the Department of Vegetable Crops, University of California, Davis. He will study post-harvest physiology of fruit and vegetables and left at the end of July.

Mr. M. V. Burton has been appointed Senior Lecturer in Agriculture and Agronomist at Roseworthy College and commenced his duties early in May. Previously, he was the Manager at the Minnipa Research Centre, Department of Agriculture.

Dr. J. Melville, Mr. A. G. Strickland, and *Mr. H. P. C. Trumble* have been appointed to the Bushfire Research Committee to enquire into economic methods of land use for bushfire control. Dr. Melville is the chairman and Mr. Trumble is the secretary of the Committee.

Dr. A. W. Moore, formerly of the Soil Conservation Branch of the Department of Agriculture is on leave for 3 months from the University College, Ibadan, Nigeria, where he is a lecturer in agriculture. He obtained his doctorate of philosophy at the University of Nebraska, U.S.A. He will return with his family to Ibadan at the end of September.

Dr. A. A. Dawson has been elected to Corporate Membership of the Institute. He is working with the Department of Agriculture as Agricultural Economist. He came from Scotland last year and has had a wide agricultural experience in various countries in the world.

Dr. P. A. Parsons, who won a Barr-Smith Scholarship to study Genetics at Cambridge is visiting Adelaide. After completing his Ph.D. degree last year, he continued his studies at Davis, California for a further 8 months. He will return to Cambridge in September, where he will work in the School of Genetics.

Western Australia

Mr. H. Lloyd-Davies and *Mr. N. R. McKeown* have been welcomed to this branch. Mr. Lloyd-Davies has transferred from Canberra to join the C.S.I.R.O. Division of Plant Industry in this State. Mr. McKeown, former Agronomist and Senior Lecturer in agriculture at Roseworthy, is working with Dr. A. J. Millington at the University Institute of Agriculture.

Mr. N. Shorter has left the Horticultural Division of the Department of Agriculture to take up a position in the Victorian Department.

Mr. R. Rees has left the North West Branch of the Department of Agriculture to join the Shell Company in W.A.

Mr. C. Ralph, formerly farming near Esperance, has returned to the Department of Agriculture, as an adviser in the Moora district. He has taken the place of *Mr. B. Carlin,* who has transferred to the Department's Bridgetown office.

Mr. D. P. Fischer, Research Officer for the Rural and Industries Bank of W.A. has been seconded to the Institute of Agriculture, where he will study recent advances in farm management research, and join the agricultural economics team in a resurvey of butterfat producers.

Professor E. J. Underwood was recently awarded the Royal Society of Western Australia's Kelvin medal. This medal is awarded every four years for distinguished scientific work in connection with this State. Judging from his activities Professor Underwood has recovered from his recent illness.

Mr. E. Bettenay and Mr. M. Churchward, both from C.S.I.R.O. Soils Division, have been in the North West, on a soil survey of the Fitzroy river area.

Branch Notes

Australian Capital Territory

In April over forty members and visitors gathered to hear Dr. E. M. Hutton of the C.S.I.R.O. Division of Tropical Pastures speak on Legumes for Queensland. Dr. Hutton compared a number of species, illustrating his remarks with kodachrome slides.

The June meeting took the form of a description by Mr. K. Wilson-Jones, Research Secretary of the Colonial Pesticides Research Committee, London, of recent development in pesticides research. The Committee that he represented sponsors research work mainly of an entomological nature throughout the British colonies. The meeting was of general interest to agricultural scientists and entomologists who were visitors to the meeting. Since speaking to the meeting Mr. Wilson-Jones has been appointed to the position of Director of the Coastal Plains Research Station, Darwin.

In July Mr. J. Phillip addressed the Branch on Agricultural Physics. Mr. Phillip is by training an engineer and has recently joined the staff of C.S.I.R.O. at Canberra where he will lead a small team studying physics as applied to agricultural problems.

The A.C.T. Branch has arranged a fairly full programme of meetings throughout this year and hopes towards the end of the year to arrange a dinner as successful as the one held last year.

New South Wales

A symposium—Science and the Efficiency of Australia's Wool Industry—was held on June 4, in conjunction with the Society of Animal Production. The Sydney firm of David Jones made its art gallery available for the meeting, gratis, and provided a buffet dinner between the afternoon and evening sessions. There were eight speakers and a wide range of topics was covered. Summaries of some of the talks appear in the Talks section. The symposium was attended by a very representative audience of over 300. It received a very wide press coverage through the efforts of W. Ritchie, the N.S.W. Branch Publicity Officer; it was given at least 350 column inches, mainly by the rural press.

Recruitment of students for Agricultural Science has been discussed by the Branch Committee and the recruitment campaign will be recommenced at the 1957 level.

A sub-committee on Undergraduate Affairs has been particularly active; it has been empowered to carry out an annual canvass of non-governmental bodies to assess the employment prospects for new graduates. An interesting development is the interviewing of prospective employers by undergraduate representatives. It is also of interest that only 14 per cent. of the present fourth year students are bonded and in the last three years, Professor McMillan has had few, if any, requests from students to assist them in gaining employment.

A symposium on Agricultural Consultants was held on July 31. In October and November, there will be symposia on Banking and Agricultural Finance and on Plant Pathology, respectively.

Northern New South Wales Sub-Branch

A general meeting was held at Inverell on July 11. It has been the policy of this Sub-Branch, since its inauguration in 1955, to hold at least one meeting each year at a centre other than Armidale. Successful meetings have been held at Lismore (1956), Glen Innes (1957), Tamworth (1958), and the 1959 meeting at Inverell was just as successful. A member at one of these centres arranges a local programme for the meeting and it has been found that two or three facets of agriculture can be covered during an afternoon. This excursion type of meeting has appealed to the grazier members and the scientific specialists alike.

The Inverell meeting commenced with an inspection of a seed cleaning machine recently installed at Inverell. Hitherto cereal, forage, and pasture seeds had to be cleaned at Glen Innes or Guyra and the need of a seed cleaner at Inverell might be interpreted as a reflection of the spread of improved pastures in this area.

The N.S.W. Soil Conservation Research Station at Inverell is engaged in testing and evaluating various summer growing species for erosion control. Plots of these species on granite and euchrozemic soils north of Inverell were inspected on the way to Graman where the subject changed to entomology. Here Mr. T. Burke (entomologist), and Mr. J. Fahy (agrostologist), explained their work on *Othnonius batesi*, a pasture grub which occurs in northern New South Wales and southern Queensland, mostly on heavy black soils. The severity of the infestation was clearly seen at Graman where Mr. Burke is working out the life history of this native scarab. Damage is severe on a wide range of crop and pasture species, including wheat, phalaris, and mintweed. The adult is short lived and the damage is caused by the larvae which live underground and feed on the plant roots. It is estimated that 300,000 acres are infested by this grub.

The evening meeting held at the Soil Conservation Research Station was devoted to Institute affairs, followed by an illustrated talk on the research work of the Station by Mr. K. Buckley.

Victoria

The Refresher School in Animal Sciences was held at Burnley Gardens from August 31 to September 3. A widely representative audience heard twenty one papers presented and considerable discussion followed each address.

The Branch was pleased to welcome a number of Indian Post-Graduate Fellows to the School.

A social function was held on the first evening of the School when the opening ceremony was performed. This proved to be a great success and enabled visitors to meet for further discussions.

A Branch Sub-Committee on working conditions and opportunities for Agricultural Scientists in State Government Authorities has concluded its report. which is now being considered by the Committee. It is felt that this has been a very useful activity and has provided further proof of the effectiveness of the Sub-Committee set up within the Branch.

In order to maintain a closer liaison with country members the Branch has appointed Country Correspondents in each of the main country areas throughout the State. It is proposed that these correspondents will provide the Branch Secretary with news of members' activities in each area and will act generally in a liaison capacity for their particular group.

Queensland

At the ordinary general meeting on May 27, a forum type session was held to discuss the topic "Is the Institute dead, if so, why don't we bury it." Dr. D. O. Norris and Mr. W. J. S. Sloan rejected this proposition and upheld the value of services given by the Institute to members and agricultural science. Dr. L. G. Miles and Dr. B. R. Champ disputed the value of these services pointing out discrepencies between services rendered to members and those which members should reasonably expect. In the discussion that followed the audience affirmed that the proposal should be rejected.

A social evening for members and guests was held on June 17, at the Manhattan Gardens Compass Room and was a successful repetition of a similar evening held in October last year. Mr. C. S. Christian showed a series of coloured transparencies of remote parts of Australia. Mr. J. Wolfe then presented his impressions of three states of the United States which he visited recently.

The June ordinary general meeting was directed to Notes and Exhibits.

Mr. B. Brett, a Technical Officer of Houghton and Byrne (Q.) Pty. Ltd., outlined the organisation and methods involved in a contract in which 2,643 Housing Commission homes were fumigated with methyl bromide to control an introduced species of pine borer.

Mr. R. Colbran, a Nematologist in the Department of Agriculture and Stock, showed slides he had taken recently on a study trip in U.S.A. They illustrated disorders of plants caused by nematodes, and modern machinery used for soil fumigation.

Mr. P. Kerridge, a Research Scholar of the University of Queensland discussed a native legume (*Psoralea eriantha*) which is able to grow under a wide variety of pastoral conditions. He suggested that this plant might be useful for provision of much needed protein in the diet of grazing animals in the drier pastoral areas of the State.

Mr. D. Mitchell, a Dairy Technologist of the Department of Agriculture and Stock illustrated the carton method of packing milk. After discussing details of the development and manufacture of the pack he considered hygiene aspects and commented on its applications in milk distribution and its convenience.

Dr. P. Skerman, a Senior Lecturer in Agriculture at the University of Queensland, discussed possible methods of control of *Harrisia* cactus which has become established in Brigalow country and elsewhere. He outlined control being undertaken by the Lands Department and showed coloured slides of swathes bulldozed through standing timber to facilitate arsenic pentoxide spraying in the Bowen-Collinsville district.

A symposium Water for the Farm was presented at the July ordinary general meeting. Contributing speakers were Mr. G. E. McDowell, Chief Irrigation Engineer of the Irrigation and Water Supply Commission, Mr. A. I. McCutchan, Senior Engineer, Water Resources Branch, I.W.S.C. and Mr. K. M. Carmichael, Senior Engineer, Rivers and Streams Branch, I.W.S.C.

The first speaker dealt with water conservation on the farm describing conservation of rainfall in the ground and conservation of run-off water for stock, domestic water supplies and irrigation. He then discussed selection of storage sites and their design and construction, the relationship between catchment area, storage, and irrigation area and finally water conservation beyond the storage. The second speaker considered water supply from bores and wells describing the occurrence of groundwater, its forms, zones, pressure, and availability, and the general features and quality of water from rock and alluvial supplies. He then gave details of bore and well construction, screening, development, and testing and finally described the functions of the Groundwater Advisory Service of the Irrigation and Water Supply Commission. The third speaker considered community irrigation schemes describing their requirements, the procedure followed in the original investigations and assessment, and construction and maintenance of the water reticulation schemes.

South Australia

Mr. W. K. Rose, who is a Veterinary Officer in the Department of Agriculture, addressed the Branch on June 19, on Artificial Insemination. He traced the history of artificial insemination and discussed its present day use. Mention was made, also, of the trials being done in South Australia at the present time. Two films, one produced in Australia, the other in the U.S.A., gave a very good idea of the techniques used.

At a meeting on July 17, Lady Eve Balfour spoke on The Work of the Haughley Agricultural Research Foundation.

Tasmania

Recently admitted to corporate membership were: Marcus Blacklow, who is an Assistant Agronomist in the Tasmanian Department of Agriculture and working on weed control problems. John Burdett, Assistant Plant Pathologist, Department of Agriculture, who is mainly concerned with nematology. Ron Biggs, a Science graduate from Melbourne who has been working as an Assistant Entomologist, Department of Agriculture, for 12 months. Dieter Grant-Frost, who has recently moved from Western Australia and is working with the Shell Chemical Company. Doug Fergusson, who has been working as an Agricultural Economist with the Department of Agriculture for some years and has recently graduated B.Ec. (Tas.). Barry Thistlewaite, Assistant Horticultural Research Officer, Department of Agriculture, engaged in research on rootstock propagation and cultural practices in deciduous fruits. Ian Wood, Assistant Agronomist, Department of Agriculture, working on quality problems in blue peas.

Dr. J. Wilson, a former member of the Tasmanian Branch Committee, now lecturing at Melbourne University has agreed to act as Tasmanian Proxy Delegate to Council.

On May 27, Dr. G. C. Wade addresesd an open meeting in the Lord Mayor's Reception Room at Hobart on Impressions of Agricultural Education and Research in North America. Dr. Wade gave an outline of the type of training received at secondary and tertiary levels, with particular reference to the training of agricultural scientists. He illustrated his address with colour slides of many of the research institutions and research projects which he visited during his travels in the U.S.A., and Canada, as a Commonwealth Fund Fellow.

A general meeting, on June 19, considered a number of business matters. The committee's plans to hold a symposium on The Legume in Tasmanian Agriculture were endorsed. The symposium is to be held in Launceston towards the end of the year and detailed arrangements are to be made by a northern sub-committee. There was some discussion of the William's report and a sub-committee has subsequently been set up by committee to collate further information. The main business was a consideration of views on the Faculty of Agriculture. Committee was directed to consolidate the discussion at the meeting and present a report on branch views on the course, to be discussed at a subsequent meeting.

On July 17, Mr. C. A. Holland addressed an open meeting in the Physics Lecture Theatre, University of Tasmania, Sandy Bay, on Education in the Philippines. Mr. Holland outlined the work he did with F.A.O. and showed a very interesting and colourful series of slides illustrating the lives, work and problems of the people.

Following seven recent admissions and two terminations, total branch membership now stands at 60. Several further applications for membership have been received.

Western Australia

There has been a great deal of discussion within the Branch recently as to what the Institute should do about salaries and status of members. A report submitted by a special subcommittee met with criticism from some members who strongly disagreed with recommendations that the Branch and the Institute should take some direct action on the matter. Others felt this would be quite justified. Recommendations in the report have been put to a postal vote.

Farmer—Scientist Joint Conference

The branch has agreed to join the Farmers' Union in organising another Joint Conference in 1960. Although we had not intended to hold this conference annually, the past two conferences have been so successful and the Farmers' Union so keen to hold one next year that the branch readily agreed to the proposal.

Proceedings of the last conference will soon be available.

General Meetings

Recent meetings have been addressed by Mr. E. T. Bailey, and Dr. H. P. Schapper.

Mr. Bailey described some of the promising plants found on his recent visit to Chile, and gave his impressions of that country and its agriculture.

Dr. Schapper's theme was the characteristic poverty of India and its people. He outlined the social, economic and agricultural organisation of the country, and described its government's attempts to promote economic growth. Dr. Schapper recently attended a conference of agricultural economists in India.

At the meeting held on July 27, short talks were given by Mr. A. Humphries on *Hyparrhenia hirta*—a promising pasture species—Mr. F. Roberts, on Movement of Potash in Soils, and Mr. J. Parish on Research in Wheat Qualities.

Obituary

SIR IAN CLUNIES ROSS

The death of Sir Ian Clunies Ross, C.M.G., D.V.Sc., D.Sc., A.R.C.V.S., LL.D., F.A.A., Chairman of C.S.I.R.O., on June 20, brought to a close the career of one of the most notable of our members of the Australian Institute of Agricultural Science. Recognized throughout Australia and in many parts of the world for his outstanding qualities as scientist and public figure, he nevertheless contributed in a special degree to the advancement of agricultural science and the betterment of its members, for which we remember him with our deepest gratitude.

Educated at Newington College, Sydney, he graduated Bachelor of Veterinary Science with honours from Sydney University in 1921. His post-graduate research both overseas and at the C.S.I.R. McMaster Laboratory in the field of veterinary parasitology made an outstanding contribution to our knowledge of the behaviour and control of internal parasites for which he received the degree of D.V.Sc. in 1928. His book "The Internal Parasitic Diseases of Sheep" prepared in conjunction with H. McL. Gordon is a standard text in this field.

As Officer in Charge of the McMaster Laboratory during the nineteen thirties, he was closely associated with the pastoral industry. He undertook a sheep and wool survey in north east Asia for the Commonwealth government in 1935, and later served as Chairman of the International Wool Secretariat in London. He returned to Australia in 1940 as Professor of Veterinary Science at Sydney University.

His more direct contact with agricultural science came in 1942 when he was appointed Director of Scientific Personnel during World War II., and later with his appointment, first as Executive Officer of C.S.I.R. in 1946, and then as Chairman of the reconstituted C.S.I.R.O. in 1949.

In this position, his official duties brought him into contact with people in all walks of life, and he was ever ready to make himself available to the never ending stream of requests for talks and his attendance at public functions. In spite of these demands he seized every opportunity to devote the maximum amount of time to personal discussion with his research men in the laboratory or on the field station. He loved nothing better than to roam the fields of his many grazier friends or walk between the experimental plots of the research workers of C.S.I.R.O. or State Departments of Agriculture pondering their problems and seeking how best to apply science in bettering production.

The broad outlook was not restricted to his beloved soils, plants and animals, but extended throughout all his interests. University education and welfare continued a primary interest throughout his life. He worked for years for the appointment of a Commission to report on the Universities and on the appointment of the Murray Committee served with considerable distinction in producing their memorable report. Despite his personal excellence in science he spoke on many occasions of the imperative need for breadth of training, of stress on the humanities and of the need for study of the social sciences.

His frequent international contacts, particularly amongst the peoples of central and south-east Asia led him to take a keen interest in foreign affairs and international relationships. He took an active part in promoting these both within Australia and outside and on many occasions he publicly advocated a change in the proverbial Australian policy towards restricted migration.

To the many who knew him personally, he will stand forever as one of "Nature's gentlemen," an outstanding leader of this age, a truly gifted orator, but above all, a man who gave unstintingly to one and all who asked his help.

H. C. FORSTER

ANDREW MALCOLM STEWART

Andrew Malcolm Stewart, Reader in Agriculture and Assistant Director of the Institute of Agriculture, University of Western Australia, died in June this year after a long illness.

Born in South Africa in 1904, he arrived in Western Australia with his parents at an early age. He entered the University as a student in 1927, following six years of farming experience at Wagin, during which time he founded the "Solai" Peppin Merino Stud.

After graduating, B.Sc. (Agric.) in 1930 he spent a year at the Wool Research Institute at the University of Leeds, returning to Western Australia and again taking over the farm at Wagin until he was appointed Lecturer in Agriculture at the University in 1937. In 1943 he was appointed Senior Lecturer and Assistant Director of the Institute and in 1949 Reader in Agriculture. On two occasions he acted as Dean of the Faculty.

Mr. Stewart's sympathetic understanding of student difficulties made him friend and adviser to a whole generation of agricultural graduates. His research interests were related particularly to the nutrition and breeding of the wool sheep and he made notable contributions to our understanding of such important problems as canary stain and tenderness and break in wool. He also played a prominent part in the investigations of the north-west pastoral environment.

Mr. Stewart was at all times an active member of the Institute and was president of the Western Australian Branch in 1940.

JAMES FRANCIS McHUGH

Members learnt with regret of the death of James Francis McHugh in a road accident during July. Frank McHugh was a Research Officer with the Victorian Department of Agriculture at Rutherglen Research Station, where he was largely concerned with sheep investigations. At the time of his death, he was President of the Northern Victorian Sub-Branch of the Institute.

The Branch extends deepest sympathy to his family.

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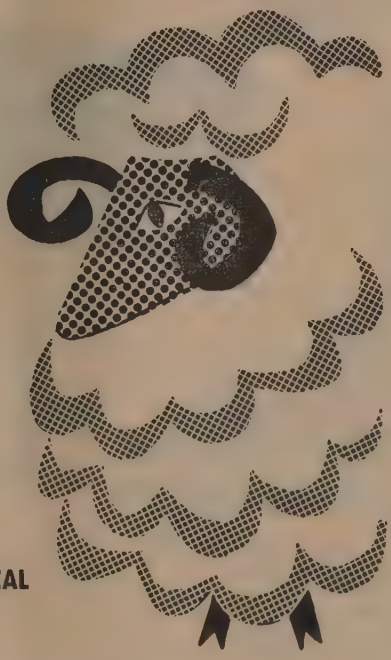

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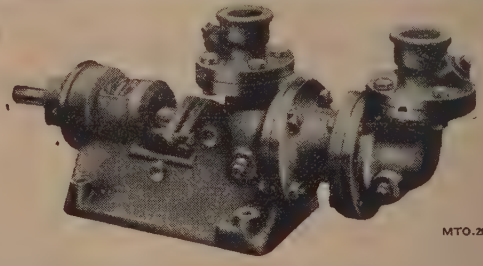

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Book Review

Diet in Relation to Reproduction and Viability of the Young. Part II. Sheep: World Survey of Reproduction and Review of Feeding Experiments

By W. Thomson and F. C. Aitken

Commonwealth Bureau of Animal Nutrition (*pp.* 93). *Obtainable from the C.A.B. Liaison Officer at* 314 *Albert Street, East Melbourne, C.2., Victoria. Price* 37/6d..

This, the latest Technical Communication to come from the Commonwealth Bureau of Animal Nutrition, fully maintains the high standard set by its predecessors. Clearly and concisely written, it brings together in one volume the sum of the world's knowledge of the relationship between feeding and reproduction in the ewe and the ram.

The authors are both well-known to Australian agricultural research workers; Mrs. F. C. Aitken (nee Russell) as author of a previous best-selling technical communication which dealt with major and minor element deficiencies and excesses in pastures, and their effects on animal health and production, and Mr. W. Thomson by his research writings, and also personally, for he recently toured Australasia. Mr. Thomson has included much of the previously unpublished material collected during his tour in the present volume, and for this reason the work is of particular interest to Australian workers.

The book is divided into two parts. The first part presents a world survey of reproduction in the sheep and this the authors rightly claim is "a fair and representative picture of sheep reproduction since records become available." Most of this material is presented in tabular form, and all of the original sources are listed. The tables contain a wealth of information which has been uncovered from the journals, many of them not in general circulation, of all countries from Peru to Albania, from the Falkland Islands to the U.S.S.R. Every extension officer, research worker, and teacher, who is interested in sheep husbandry will be fascinated by these records and all will find the mass of information, which is ably summarised in the accompanying text, a great help in their own work. It will make many Australian readers envious to read of the high lambing percentages commonly achieved in other countries such as the 211 per cent. obtained from the milk sheep of Westphalia, and they will marvel still more at the lambing percentage of 301 obtained from pure bred Romanov sheep in a state stud in the U.S.S.R.

The second part of the volume discusses the effect of diet on reproductive performance. The influence of plane of nutrition before and during pregnancy on reproduction and lactation in ewes has been the subject of considerable argument in many countries of the world. The literature on this subject is now comprehensively reviewed, and the lucid commentary that is given should go far to settle the matter for good.

The effects of individual nutrient deficiencies and excesses on reproductive efficiency are discussed fully, and finally the nutrient allowances recommended by the authorities in different countries are critically examined and compared. This comparison has been made possible by calculating starch equivalents, total digestible nutrients, and Scandinavian feed units in terms of net energy in calories, and this section will be of particular help to those who have to give practical advice to the farmer on how best to feed his breeding ewes.

The preparation of this slim volume must have taken several years, but it was time very well spent for this is likely to remain the standard reference on the subject for a long time to come.

W. IVES.

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